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Task Order 17
SIMULTANEOUS AND NON-INTERFERING (SNI) ROTORCRAFT OPERATIONS

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1.0 INTRODUCTION

1.1 Background

The helicopter industry has long believed that the efficiency of instrument flight rule (IFR) rotary- and fixed-wing operations are constrained by having to operate within the fixed-wing air traffic control (ATC) structure in both the terminal and en route environments. Helicopter takeoffs and landings are delayed by waiting to be sequenced into the landing pattern and fixed-wing aircraft also experience loss of efficiency when operating behind the slower rotorcraft. The unique operating capability of rotorcraft that allow these aircraft to takeoff and land without need of runways is not being fully employed. This capability has engendered the question of whether there is a need to develop a complementary and integrated IFR operating environment for these aircraft. With the development of new technologies that support navigation via satellites such as Global Positioning System (GPS) and the potential application of innovative ATC procedures, the probability of creating new procedures that permit rotary- and fixed-wing aircraft to conduct simultaneous approaches and departures without affecting or interfering with each other does exist. Of particular interest are operations at busy metropolitan airports where the potential exists for conflict between rotary- and fixed-wing aircraft using the same IFR approach and departure procedures during instrument meteorological conditions (IMC).

1.2 The SNI Concept

The possibility of designing non-conflicting procedures is provided for in the Federal Aviation Administration (FAA) “Rotorcraft Master Plan” (1990) that states that developing a system to satisfy increasing demand for IFR rotorcraft operations within the national airspace system (NAS), especially in the northeastern United States, has been a long-term charge of the aviation community. This plan has the support of some sectors of the helicopter industry who see that confining rotorcraft to fixed-wing procedures as a constraint to efficient helicopter operations.

However, a question has arisen whether “real world” operations warrant developing IFR helicopter procedures that would allow simultaneous non-interfering (SNI) rotorcraft operation. Are the levels of rotorcraft IFR operations sufficient to impact the efficiency of both rotary- and fixed-wing operations on a regular basis? Would implementing SNI be beneficial for relieving these impacts?

The operational capabilities at Philadelphia International (PHL), Newark International (EWR), Teterboro (TEB), and New York’s LaGuardia (LGA) airports and the associated interconnecting airspace were selected for this investigation. These airports were selected because they contain the required airspace configuration, level of operations, IFR procedures, aircraft mix, and weather conditions for such an investigation. These airports also provide a range of detailed traffic patterns, airspace jurisdictions and responsibilities, and published approach and departure procedures that dictate flow patterns for both rotary- and fixed-wing air traffic.

1.3 Objective

The objective of this task was to assess the degree to which both rotary- and fixed-wing IFR operations at the four selected primary airports are impacted by IFR rotorcraft operations by identifying the current “real world” operational environment. This assessment also helps to define further work in support of the SNI Operations concept.

1.4 Approach

The current environment within which rotary- and fixed-wing operate were investigated by evaluating several aspects of their operations. These include:

- rotorcraft IFR approach and departure routes,
- on-airport heliport activity,
- benefit of multiple arrival and departure paths,
- altitude restrictions,
- transition point between terminal and en route,
- proposed GPS-based low altitude structure, and
- application of GPS to approach and departure procedures where appropriate.

1.5 Investigative Process

The investigative process was performed in two steps. First, was a review of all applicable documentation to include FAA Orders (FAAO), local operating directives, and applicable regulations contained in the Code of Federal Regulations (CFR), as well as any additional FAA and helicopter industry publications.

Second, was to conduct an investigation of current terminal operational procedures through interviews with ATC personnel and local helicopter operators. The impact of operational techniques, rule adaptations, and handbook interpretations on rotorcraft operations were evaluated by on-site visits and personnel interviews at ATC facilities at the selected airports.

Telephone interviews were conducted with local area helicopter operator who frequently use the study airports (PHL, EWR, TEB, and LGA). These operators and pilots were interviewed to determine how they operate at each airport within the current system and how that system affects the way they operate, any problems they encounter and if they experience any conflicts with fixed-wing aircraft.

In addition, regional and national rotorcraft support organizations, such as the Eastern Region Helicopter Council (ERHC), New England Helicopter Pilots Association (NEHPA), Mid-Atlantic Helicopter Association (MAHA), American Helicopter Society (AHS) and Helicopter Association International (HAI) were contacted in the initial stages of this project. They were asked about their issues and concerns regarding possible SNI processes and to name individuals who could make a contribution to the data collection effort.

2.0 CURRENT OPERATING ENVIRONMENT

2.1 Operational Parameters

This section describes the operational environment found in both the terminal and en route airspace that services all four study airports. It outlines existing operational techniques as prescribed by FAA rules, orders and regulations including any rule adaptations and handbook interpretation applied by ATC in handling these operations. It presents the history and status of the Northeast Helicopter Corridor and why this area is considered applicable to the study topic. It examines future technologies that could supplement ground based navigation system. In addition, it depicts the configuration and operational characteristics of each study airport and how each currently handles rotary- and fixed-wing IFR traffic. Insight into the way the operators use the current system and their issues and problems with both IFR operations and individual airports is provided through the results of the helicopter operator interviews.

2.1.1 FAA Orders and Regulations

The overall system has remained constant. The majority of existing procedures that support instrument flight were developed to focus primarily on fixed-wing activity. Although the level of rotorcraft traffic has continued to increase in the northeastern United States, it is still a small percentage of the total air traffic activity. In performing an in-depth review of applicable FAA Orders and associated Federal Regulations, it is evident that the baseline airspace design focuses on separation and sequencing standards for the fixed-wing aircraft fleet. With the exception of the recently published GPS non-precision terminal instrument procedures (TERPS) criteria, rotorcraft procedures have been a subset of fixed-wing criteria and have not fully exploited the unique operating characteristics of rotorcraft.

2.1.2 Tower En Route Control (TEC) Service

A key area investigated was the Tower En Route Control (TEC) service. This service has been offered for a number of years to users of the aviation system in an effort to increase capacity in the low altitude structure for short-range flight operations of two hours or less. The primary support comes from inter-facility agreements with a specific Air Route Traffic Control Center (ARTCC) that allow terminal radar approach control (TRACON) to TRACON handling of air traffic. The structure is primarily supported by the conventional very high frequency omni-directional range (VOR) airway system using ground-based navigational aids (NAVAIDS) in conjunction with standard arrival routes (STARs), preferential IFR routes, and standard instrument departures (SIDs). These routes continue to be published in the "Airport/Facility Directory" and offer a variety of alternatives between locations.

After a number of years of operation there are still shortfalls with regard to TEC supporting rotary-wing operations in the northeastern United States. As identified in other studies, there is still a lack of rotorcraft specific routes connecting heliport to heliport, airport to heliport, and heliport to airport. Even with publication of GPS specific non-precision rotorcraft instrument approach criteria, only a limited number of public-use instrument approach procedures (SIAPs) have been developed that could connect TEC operations for rotorcraft.

2.1.3 Northeast Helicopter Corridor

Rotorcraft traffic operating between Washington, DC and Boston, MA was provided with an independent IFR system known as the Northeast Helicopter Corridor (Appendix A). The corridor provided a set of non-conflicting north and southbound area navigation (RNAV) airways. It was developed to demonstrate the feasibility of IFR helicopter operations in high-density traffic areas. Airspace configuration, operations, and procedures in this congested airspace made it the perfect operational environment to serve as a test case. The main emphasis was to minimize impact of rotorcraft operations on the ATC system, while providing a stand-alone network for rotorcraft separate from most fixed-wing traffic.

Development centered on the lack of compatibility between rotary- and fixed-wing airspeeds and the premise that rotorcraft do not have to go to an airport in order to transition from an IFR environment. This assumption remains valid, although over the years its significance has diminished as has its non-interfering and independent routing. The non-interfering and independent routing seems to be in question. As operations have changed in that region, the corridor no longer provides the same level of service as it was originally intended.

Although a variety of segments is still in use today, overall activity has decreased. Most air traffic controllers do not associate the name "Northeast Helicopter Corridor" with their route assignments that use specific segments of the corridor. Issues associated with limited radar coverage, lack of public-use SIAPs, and most important, no connection between conventional routes and the corridor, have contributed to an erosion of its operational effectiveness. These and a number of other operational factors went into its development, but unfortunately, it seems to have fallen victim of its shortcomings.

2.1.4 Experimental Northeast Helicopter Corridor IFR Low Altitude Route

In July of 1995, as a result of a government and industry joint effort, the government published a revised Northeast Helicopter Corridor chart, titled the "Northeast Corridor IFR Low Altitude Helicopter Route." The revised chart extended the southern limit from Washington DC to the New River Marine Corps Air Station, NC. Unlike the original chart, this chart does not use RNAV by off-setting the course from the airway route structure. It provided a GPS overlay that closely matches the current route, adding waypoints throughout as specific reporting and clearance points. This chart is experimental and is only authorized for visual flight rules (VFR) test purposes. After discussions with ATC and rotorcraft operators, it is evident that very little is known about these routes. Furthermore, neither government nor industry was able to provide any information on the test or plans for future work.

2.1.5 Special Visual Flight Rules (SVFR)

As a result of the interviews conducted at each ATC facility and with local rotorcraft operators, it is evident that use of special visual flight rules (SVFR) significantly contributes to success of rotorcraft operations during marginal weather conditions. For the most part, SVFR operations are conducted using the same routes and procedures as VFR, except ATC provides separation. Since participation in IFR normally results in some form of delay for rotorcraft, most operators choose to conduct their operations under SVFR. SVFR operations for fixed-wing aircraft under these conditions is not authorized except with an exemption. Therefore, a level of non-interference is afforded rotorcraft during these marginal conditions.

Although a visual procedure, SVFR is considered an IFR operation that requires a clearance. ATC operates on a first come, first serve basis in providing rotorcraft access via SVFR to-and-from heliport facilities or in-and-out of airport environments. The weather minimums imposed by SVFR only require that rotorcraft remain clear of clouds. In addition, some operators have developed an independent set of weather restrictions for day/night SVFR operations, shown in Table 2.1.4 – 1. Even so, SVFR allows virtually unrestricted access in most controlled airspace and has significantly enhanced rotorcraft operability.

Table 2.1.4 - 1 SVFR Minimums

Time of Day	Ceiling	Visibility
Day	500 feet	2 miles
Night	800 feet	2 miles

2.1.6 Uncontrolled Airspace

Uncontrolled, or Class G airspace, is that portion of the airspace that has not been designated as Class A, Class B, Class C, Class D, or Class E. Flight in this airspace has not been a problem for rotorcraft operations. There are specific rules for VFR flight designed to assist pilots in meeting the see-and-avoid requirement to operate in Class G airspace. In addition, IFR operations levy pilot and aircraft equipment requirements for flight in Class G airspace. Pilots must maintain a specific altitude in direct relation to their magnetic course or ground track. Vertical and lateral clearance standards are also mandated that require at least 1,000 feet (2,000 feet in designated mountainous terrain) above the highest obstacle within a horizontal distance of four nm from course.

2.1.7 Communications

Frequency congestion can be a problem in any environment, especially in a high volume terminal area that handles both fast and slow moving air traffic. Aside from standard frequency assignments that are provided for routine VFR and IFR operations, ATC has designated additional frequencies for SVFR operations. For the most part, there does not appear to be any problems with regard to frequency assignments in the study area. Although, if additional services are required to support the SNI concept, it will be necessary to ensure adequate coverage is provided throughout the entire network of flight.

2.1.8 Navigation

2.1.8.1 Global Positioning System (GPS)

Previous investigative efforts focused on a view that the GPS will provide the answer to a number of navigational difficulties that have occurred throughout the past few decades. As a prime example, the concept of developing SNI procedures is based on the premise that GPS offers the needed navigational availability to support a low-altitude network for both terminal and en route operations. For the most part, this statement is accurate, but with a few exceptions. To achieve the needed accuracy, integrity, continuity, and availability, additional work is necessary. In a recently published report by the Johns Hopkins University Applied Physics Laboratory (JHU/APL) (Appendix B), all of the known risks were assessed. Their primary conclusions revealed that GPS must be augmented in order to meet the operational standards necessary to function as a sole source for navigation in the NAS. In short, the report stated:

- GPS with appropriate local area augmentation system (LAAS) and wide area augmentation system (WAAS) configurations can satisfy the required navigational performance to function as a sole source for navigation.

- Risks to GPS signal reception can be managed, but steps must be taken to minimize the effects of intentional interference.

- A definitive national GPS plan and management commitment is needed to establish system improvements with civil aviation users and provide greater informational access to the civil aviation community.

Even with this, GPS does offer hope in the near-term for developing an independent IFR infrastructure. As the result of a 1993 test program supported through a partnership between government and industry successes have been achieved. In June of 1994 the FAA was able to demonstrate and commission a stand-alone non-precision GPS approach to a heliport and a supplemental type certificate (STC) for GPS installation to the rotorcraft fleet. The benefits of this non-precision GPS approach at Erlanger Medical Center in Chattanooga, TN were quickly realized. Within a few months of being published, the medical center had credited thirty lives saved due to the availability and use of the approach procedure to the hospital. In June 1997, the FAA published an additional order, FAAO 8260.42A, that permitted the development and publication of non-precision GPS SIAPs. The only provision was that rotorcraft GPS airborne equipment meets the requirements of TSO-C129a, “Airborne Supplemental Navigation Equipment.”

Although since its inception and publication, little has been done by the government to increase the number of stand-alone public-use non-precision GPS SIAP servicing the many heliports throughout the United States. Change is slow, but the potential to enhance and accelerate rotorcraft IFR operability is vested in GPS technology and should be exploited.

2.1.8.2 Very High Frequency Omni-Directional Range/Distance Measuring Equipment (VOR/DME)

The service volume of the network of VOR/DME NAVAIDS that supports that portion of the NAS in the northeastern United States is adequate to provide coverage within most of the terminal and en route areas that were part of this investigation. Unfortunately, they are subject to line-of-sight restrictions and coverage may be limited in some isolated en routes areas.

The Northeast Helicopter Corridor was designed around the use of these VOR/DME NAVAIDS to provide route guidance through RNAV where possible. The unique characteristic of RNAV routes is that they require only one half the width of a typical Victor Airway. The level of safety is not diminished, but accuracy of the system is enhanced and credited appropriately. The principle was ideally suited for low-altitude rotorcraft navigation in metropolitan areas, which usually have a high number of ground obstacles. Based on the proximity of these obstacles, the narrower RNAV airway could be charted in such a manner as to avoid them while providing guidance at a considerably lower altitude. However, a number of other factors restricted the altitude spectrum.

2.1.8.3 Instrument Landing System (ILS)

The instrument landing system (ILS) is designed to provide an approach path for precise alignment and descent of an aircraft on approach to a runway. Both the localizer and glide slope transmit a navigational signal that is extremely narrow and unusable when considering off set approaches for rotorcraft that would permit alignment to another landing site other than the servicing runway. However, the ILS is still a very useful tool for rotorcraft and at LGA, TEB and EWR where separate “copter SIAP” have been developed to support rotorcraft operations to specific runways. The advantage of these procedures is that they offer a precision approach capability to a specific runway with significantly reduced minima. However, rotorcraft are kept in the normal flow of traffic until, depending on the weather, the aircraft can transition to an alternate landing site or exits the runway.

Aside from its limitation, the importance of the ILS should not be underestimated because it is the only precision approach aid available today. Since the latter part of 1994, the FAA has had an ongoing research and development (R&D) initiative investigating use of GPS to provide a precision approach capability. Issues associated with deceleration and low airspeed sensing have proven to be formidable challenges and have served to divert the task from its original schedule. The FAA considers this a paramount issue and continues to pursue it.

2.1.9 Surveillance

As part of the investigation of both metropolitan areas, New York and Philadelphia, surveillance was not mentioned as a problem by either the controllers or operators. Previous reports suggest that this may not be the case. As an example, one of the deficiencies of the Northeast Helicopter Corridor was the lack of complete radar coverage on several segments of the route at the maximum assigned altitudes. Corridor altitudes varied by location and route, but on average ranged from a low of 1,700 feet above the ground (AGL) to a maximum of 5,000 feet mean sea level (MSL). The ability to provide surveillance at these altitudes is a critical element in any non-interfering procedure and is necessary to maintain positive separation between rotary- and fixed-wing aircraft.

Understanding that there were surveillance problems with these altitudes is an important issue. Although surveillance is not considered an essential element needed to control air traffic in a low-density environment, the reverse is true when addressing a high-density traffic environment. Actually, it becomes a must. ATC, as evident by the altitudes associated with the Northeast Helicopter Corridor, considered low-altitude to be in the range of 1,700 feet AGL. Discussions with the operators revealed a significantly different perspective. Their assessment of low-altitude lowered the base elevation to 500 feet AGL. The problem with regard to surveillance becomes clearly evident. If surveillance was a problem at 1,700 feet AGL, elevations as low as 500 feet AGL significantly compound the situation.

2.1.9.1 Radar

An excerpt from the radar services section of the FAA "Aeronautical Information Manual (AIM)" that explains services and procedures states, "It is very important for the aviation community to recognize the fact that there are limitations to radar service." Although radar has become the foundation of the current ATC system it still suffers from a number of limitations, the majority of which deal with the characteristics associated with radio waves that travel in a continuous straight line. This is crucial in explaining that radar coverage, or the lack of it, in areas that are screened or blocked by ground obstacles, e.g., at low altitudes where rotorcraft elect to operate, can significantly impair the availability of ATC service. Controllers cannot issue traffic advisories concerning aircraft that are not under positive control and cannot be seen on radar. Furthermore, additional control procedures are necessary when radar contact is lost. Each of these limitations can substantially reduce rotorcraft participation in instrument flight.

2.1.9.2 Automatic Dependent Surveillance – Broadcast (ADS-B)

Functionally automatic dependent surveillance, broadcast (ADS-B) is currently under development. ADS-B will be able to broadcast information, such as identification, position, and altitude from an airborne transmitter that can be received and used by a variety of applications to provide services, functions, and capabilities. For example, ADS-B information can be displayed on an ATC surveillance screen much the same way radar provides surveillance today, albeit with significantly increased performance and surveillance coverage. Furthermore, over the long term ADS-B is projected to be less expensive than current ground-based navigational systems.

ADS-B is recognized by the FAA as an enabling element of free-flight that could serve as a means of relaxing restrictions and increasing flexibility in a number of environments. It will provide, air-to-air, air-to-ground, and ground-to-ground surveillance information, with advantages in cost, coverage, and performance when compared to extending current radar-based surveillance for the same functions. The FAA maintains that surveillance of positively controlled aircraft by a combination of primary and secondary radar and broadcast of satellite-derived position information by individual flights can be merged as the next ATC standard to manage air traffic. To that extent, the FAA fully supports this concept and has incorporated ADS-B into the ATC Services (ATS) Concept of Operations as part of the future NAS Architecture.

Successes with ADS demonstration programs have proven the concept is viable. As an example, during the 1996 Centennial Olympic Games as part of Operation Heli-STAR (Helicopter Short-Haul Transportation and Aviation Research), ADS was combined with GPS navigation to provide controllers with the capability to accurately track an aircraft's position, speed, and altitude in a non-radar environment. In addition, as part of an on going investigative in Gulf of Mexico, two aspect of ADS are being examined. One deals with the air-to-air mode as it relates to enhanced threat awareness and its potential application to the see-and-be-seen rules for traffic separation in VFR operations. The other is the air-to-ground mode and how it can support improved surveillance information for air traffic management. ADS linked with satellite-derived position information provides the potential for reduced traffic separation in IFR operations. Ground facilities can receive aircraft altitude and position data even when they are not detectable on radar, and relay this information to an ATC facility to extend positive control to areas that would otherwise be considered non-radar.

2.1.10 Local Operating Directives

Except for PHL the other study ATC facilities have developed a separate letter of agreement (LOA) with the various operators that transit the associated controlled airspace. These agreements primarily focus on the use of SVFR. Although the LOA standardizes operation at a specific facility, procedures between facilities vary, adding to the difficulty of transitioning from airport to airport.

In some cases, specific procedures have been developed to support IFR departures that require a VFR or SVFR clearance. Case in point, are the IFR helicopter departure procedures from the Manhattan heliports that are provided by LGA air traffic control tower (ATCT) and New York TRACON (N90). As part of this procedure, a specific heading and altitude is provided so that the rotorcraft can transition from visual to instrument flight at a specified fix.

2.2 Philadelphia International Airport (PHL)

2.2.1 Airport Configurations

The PHL Air Traffic Facility, which consists of a ATCT and a TRACON, handles arrival and departure air traffic for the PHL area. PHL Airport is configured with a basic runway design that provides two primary east – west runways (09R-27L and 09L-27R) and one south - north runway (17-35). With the exception of runway 35 all runways have a published SIAP that provides both precision and non-precision capability. Radar approach and departure control services are provided continuously throughout the terminal area. In addition, PHL has published airport surveillance radar (ASR) minimums for all runways.

Runway alignment is contingent on the prevailing wind, but the normal setup for fixed-wing air traffic at PHL is an east to west configuration. The amount of both VFR and IFR rotorcraft traffic that transits the terminal area is very limited. The majority of rotorcraft traffic is VFR that remains outside of the PHL Class B airspace. In reviewing the arrival pattern of those rotorcraft that do proceed to the airport, most use the "Copter ILS" SIAP published for runway 17 shown in Figure 2.2.1 - 1.

Due to the prevailing weather conditions, most rotorcraft operations are conducted from the north end of the airport. Arrivals are aligned with runway 17 and departures runway 35. Both arrivals and departures are handled from taxiway Echo 1, which is used as a helipad. The primary reason for this type of approach is that most operators use the general aviation (GA) terminal facilities at the north end of the airport. An approach or departure from this location significantly reduces the ground travel distance and minimizes overall taxi time.

2.2.1.1 Controlled/Uncontrolled Airspace

The PHL airspace is primarily Class B. Generally, the core of this includes airspace from the surface up to and including 10,000 feet MSL and extends out approximately 5 nautical miles (nm), incorporating the primary airport and any other airports in the immediate area. The configuration of the Class B PHL airspace has been tailored to exclude outlying heliports. This allows rotorcraft traffic to arrive and departure from those heliports without direct coordination with ATC. The airspace itself consists of different layers of controlled airspace to contain all published instrument procedures providing arrival and departure corridors to the PHL airport.

2.2.1.2 Air Traffic Control Handoff Points

The airspace has a number of handoff points that are commonly used by both rotary- and fixed-wing air traffic. There is a portion of the Northeast Helicopter Corridor that transits the airspace primarily in a northeasterly and southwesterly direction. Victor 313R provides the northeasterly flow, while victor 314R the southwesterly flow, as shown in Figure 2.2.1.2 - 1.

2.2.1.3 Current and Proposed Operational Procedures

The small number of IFR rotorcraft operations is further explained by the fact that there are no existing memorandum of understandings (MOU) or LOAs with any local operators regarding operation within the Class B airspace whether VFR or SVFR. Based on this, there appears to be no real need for any additional control procedures. The traffic volume and level of service do not now appear to justify the need. If the volume were to increase, it might be necessary to develop specific procedures.

As part of the interview with ATC two issues surfaced that could increase the number of rotorcraft operations in the terminal area. One was the possibility of developing a non-precision GPS point-in-space (PinS) approach to the airport. PHL is authorized to run simultaneous converging instrument approaches. If a rotorcraft is sequenced in the flow, additional spacing is necessary to account for the speed differential between the rotorcraft

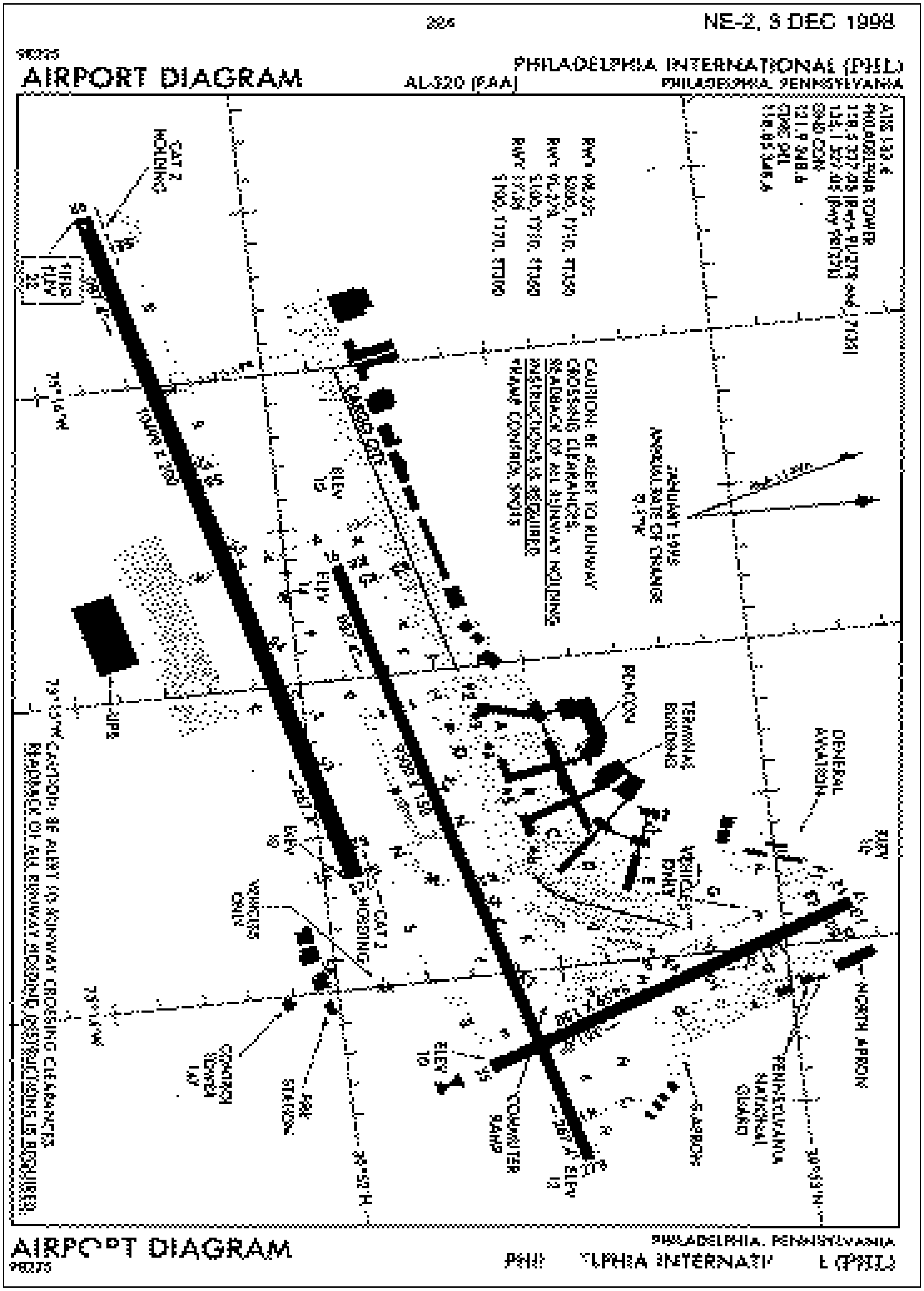

Figure 2.2.1 - 1 PHL Airport Layout

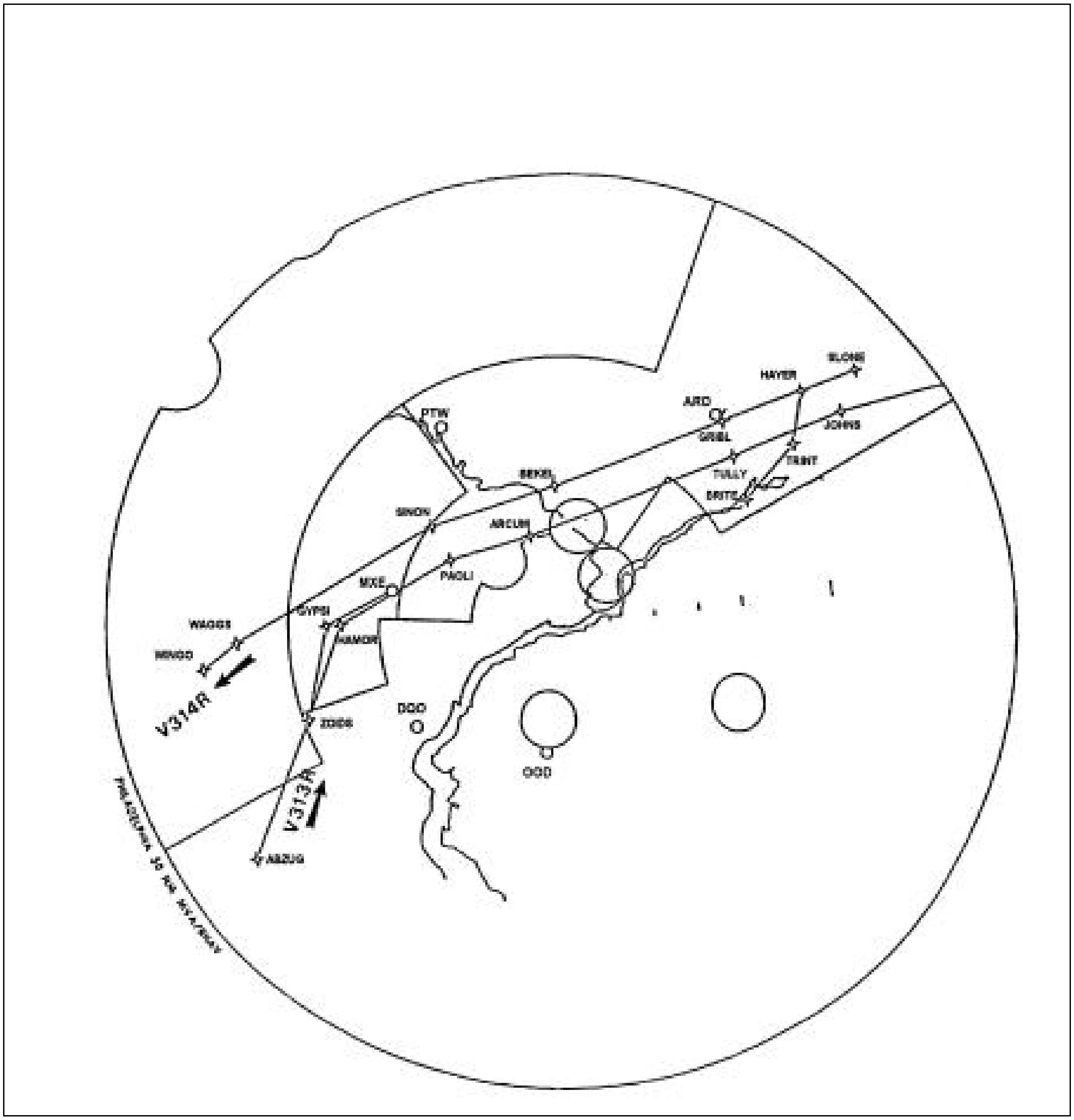

Figure 2.2.1.2 - 1 Philadelphia Victor Air Routes

and the faster moving fixed-wing aircraft fleet. If an alternate GPS SIAP from the northwest were developed it would be a first step in providing a level of procedural non-interference between rotary- and fixed-wing aircraft and possibly minimize any control conflicts. The second issue dealt with enhancing the TEC between TRACONS. Controllers stated that coordination problems have existed in the past that have apparently diminished the effectiveness of the TEC program. They suggested that by expanding the selection of available low altitude routes, coordination between facilities could be significantly improved.

2.2.1.4 Current Published IFR Procedures

As stated, with the exception of runway 35 all other runways have published SIAPs, to include ILS and ASR. The approach to runway 17 also provides a "Copter ILS" procedure. The copter approach provides a significant reduction in both ceiling and visibility requirements for rotorcraft operations in IMC. The ceiling is reduced to 100 feet, while the visibility is decreased to a quarter mile. Table 2.2.1.3 - 1 is a complete list of all current available instrument procedures at the Philadelphia International Airport.

Table 2.2.1.3 - 1 Available Instrument Procedures at PHL

Type Procedure	Runway/Designation	Type Procedure	Runway/Designation
STARS	Blunt One	SIAPs	ILS Rwy 9R (CatII)
	Cedar Lake Seven		ILS Rwy 9R (Cat III)
	Dupont Four		VOR/DME or GPS-A
	Mazie One		VOR/DME RNAV Rwy 17
SIAPs	Converging ILS Rwy 9R		NDB Rwy 27L
	Converging ILS Rwy 17		GPS Rwy 17
	ILS Rwy 9L		GPS Rwy 27L
	ILS Rwy 9R		GPS Rwy 35
	ILS Rwy 17		Copter ILS Rwy 17
	ILS Rwy 27L	Departure	Philadelphia Six (Vector)
	ILS Rwy 27R	Radar	All Rwys

2.2.2 Ground Handling Procedures

There are no special ground handling procedures for rotorcraft at Philadelphia. With the majority of approaches being executed to runway 17 the ground distance between the GA terminal and either taxiway Echo 1 is kept to a minimum. Fixed-wing traffic in the area of the GA terminal is also negligible and does not lead to a conflict with rotorcraft fleet.

2.3 New York Terminal Radar Approach Control (TRACON)

2.3.1 TRACON (N90) Configurations

The New York TRACON or N90, is charged with the arrival and departure air traffic responsibility for EWR, TEB, and LGA airports. Collectively, N90 controls one of the most complicated parcels of airspace in the NAS. The airspace is comprised of a 150 by 125 nm section that encompasses almost 19,000 square miles, for a total of approximately 50,000 cubic nm of controlled airspace that extends from the surface up to and including 17,000 feet AGL. It stretches eastward to Montauk Point, NY, on Long Island, north to the town of Kingston in Ulster County, NY, west beyond the Delaware River to the border of Pennsylvania and New Jersey, and as far south as Trenton, NJ. The actual control area encompasses portions of four states (New York, New Jersey, Connecticut, and Pennsylvania) as well as the Atlantic Ocean. The traffic volume for N90 peaks out at over 1.8 million annual operations. This represents an average daily traffic count of between 6-7,000 per day, with occasional high points in excess of 7,225 daily operations.

2.3.2 Air Traffic Flow Pattern

N90 interacts with a total of sixteen airport control towers, eight separate approach controls, and three air route traffic control centers (ARTCC). In order to handle its high volume of air traffic N90 is divided into five separate areas of operation, LaGuardia, Kennedy, Islip, Newark, and Liberty. Each has a variety of control responsibilities, but for the most part, it is designed to handle a specific flow of air traffic in and out of a primary airport. The operability of each area is dependent on the traffic volume and runway configuration at participating airports. Specific arrival and departure patterns for each area are shown under the specific airport section. After close examination of these patterns and discussions with individual controllers, the difficult level of control is evident. To that end, N90 uses an airport interaction chart that delineates the relationship of how the inter-operability between areas is managed for the three primary airports, John F. Kennedy (JFK) International Airport, LGA, and EWR. The airport interaction chart establishes the core flow patterns for all arrivals and departures within N90. Other variables, such as crosswind conditions and noise abatement procedures do enter into the picture, but to a lesser degree.

As with the Philadelphia area, a portion of the Northeast Helicopter Corridor does transit the N90 airspace. Although it is more commonly referred to as the Northeast Heli RNAV Routes, a depiction of the Newark ASR-9 video map with that routing is shown in Figure 2.3.2 - 1. While not displayed as part of the video map, waypoints and segments of the corridor that proceed to the northeast out of the LGA area are still published for use. Route references are available in the TEC section of the "Northeast Airport/Facility Directory."

2.3.3 Controlled/Uncontrolled Airspace

The airspace delegated to any of the five operation areas has borders that are clearly defined by a variety of radar video maps and facility charts. The control responsibility is further delegated to a small unit known as a sector or position. Each position has an assigned tract of airspace that is divided both vertically, with an altitude barrier, and laterally through transfer control points between other positions or control agencies.

2.3.3.1 Air Traffic Control Handoff Points

A figure is provided to depict the various arrival and departure routes in the separate sections for each airport. Each of these routes clearly displays the coordination fix/handoff point for air traffic utilizing these routes. In some cases, routes have been developed to support both turbo-prop and jet aircraft separately. The controller within each area is responsible to ensure that all routing of any aircraft originating from within that area, or initially handed-off from an adjacent facility through that area, is correct to the first airborne fix outside N90 airspace.

2.3.3.2 Current and Proposed Operational Procedures

Detailed descriptions of the standard operating procedures for N90 are published in FAA Order N90 7100.5C (2/26/98) and the "Facility Briefing Guide". The TRACON, in conjunction with the three study airports using N90 support, controls an exceptionally high volume of rotary-wing air traffic on a daily basis. Service is provided to the highest degree to ensure quality handling. In addition, the Airspace and Procedures branch of N90 works in concert with the local helicopter organizations to routinely assess rotorcraft procedures.

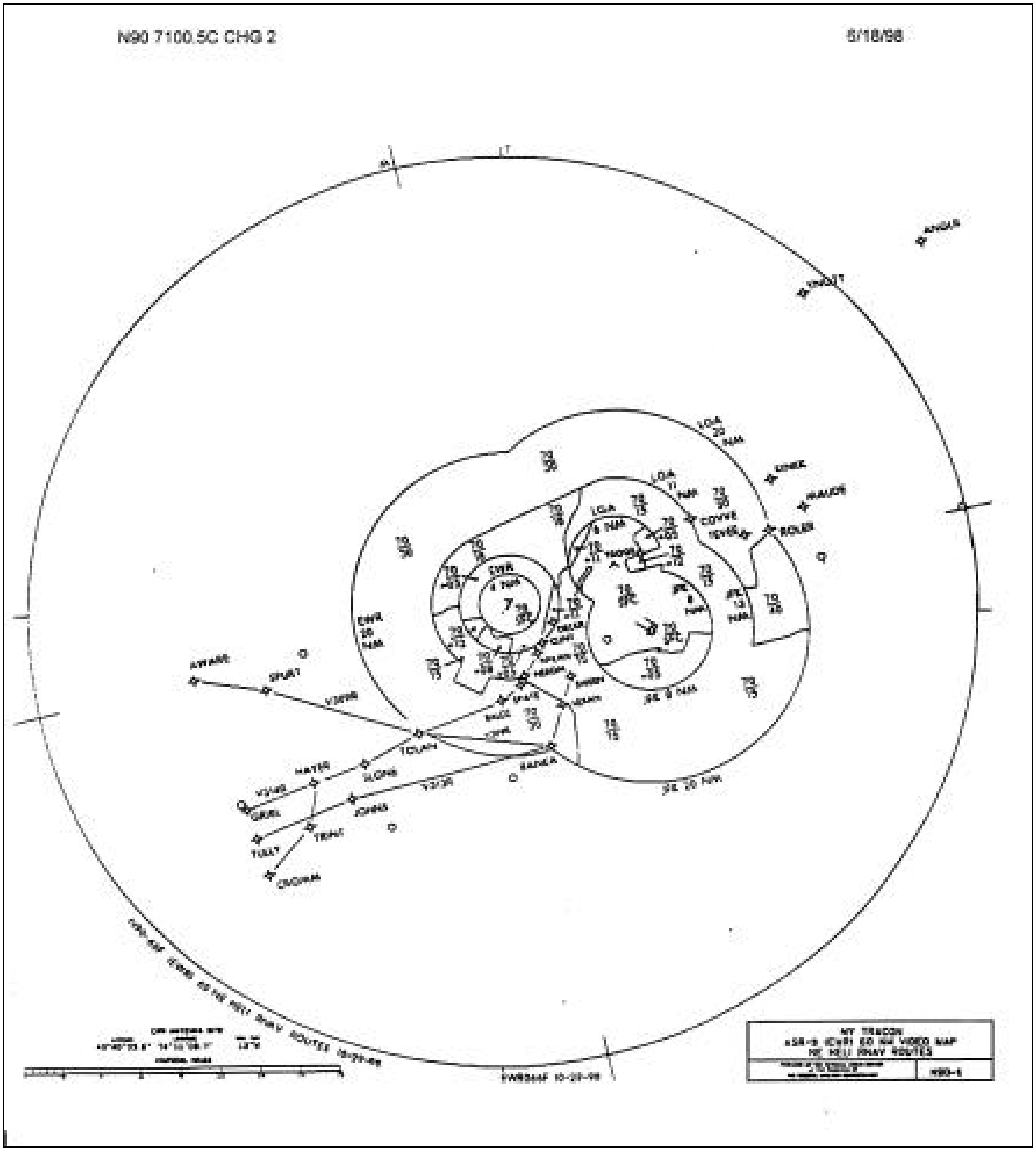

Figure 2.3.2 - 1 New York TRACON ASR-9 (EWR) 60 nm Video Map

The government has further broadened its efforts to address a number of sensitive issues through creation of the Capacity Enhancement Task Force (CETF).

As an example, in February 1996, N90 conducted a 120-day evaluation of helicopter routes proposed by the helicopter community. These routes were evaluated to determine their effect on other ATC throughout the area. In the past, many suggestions that appeared to have merit were determined unusable because of in-place arrival and departure procedures, specifically those that support LaGuardia airport. Using the current development criteria as a standard, such as prescribed separation for radar, airspace boundaries, obstructions, and specific runway configurations, a number of procedural limitations were noted. In an effort to find a workable solution, the TRACON proposed a change to the separation standards for rotorcraft by using GPS as the primary means for navigation. By requiring all participating helicopters to be GPS equipped, the TRACON attempted to achieve a reduction to the published separation standards criteria. The assumption was that the navigational accuracy offered by the GPS constellation would permit and allow these changes. The revised criteria proposed to provide a greater degree of flexibility in developing alternate routes, permitting routes to be located in areas that had previously been disallowed. The proposal was well founded, but overcome by a number of other concerns based on the ability of GPS to function as a navigation source and ensure an appropriate level of safety (Appendix C).

The main element of the proposal was to reduce the lateral, vertical, and visual separation standard, to a more beneficial dimension, which is closely aligned to the SNI concept. These efforts were designed to use GPS combined with the unique operating characteristics of rotorcraft to allow routes to be placed in areas that were more confined, yet safely navigable. Rotorcraft possess a greater degree of maneuverability and can fly at significantly slower airspeeds than fixed-wing, yet navigational standards were developed on a fixed-wing basis. The premise was good, but a number of issues need to be addressed in an effort to offer a potential SNI solution:

- The proposal needs to explain how the capabilities of current GPS and surveillance systems can support justification for authorizing reductions to separation standards, and ensure that an equivalent level of safety can be maintained.
- Procedures need to be defined for establishing equivalent levels of safety for rotorcraft operations using proposed non-standard routes that would justify an approved waiver to existing criteria.
    - How will the waypoints that define the routes be entered, by the pilot or contained in a database?
    - Are there plans to provide for rotorcraft speed and turn expansion?
    - What equipment will be required in the rotorcraft to fly these routes?
    - Will training be required or will the routes be open to the general public?
    - What consideration is given to GPS en route sensitivity?
    - Was receiver autonomous integrity monitoring (RAIM) considered?
    - Was fix displacement considered?
    - What consideration was given regarding magnetic variation errors?
    - What allowances were given to flight technical error (FTE)?
    - Has consideration been given to any errors associated with the radar display?

- Is there complete radar coverage available at the prescribed altitude of 1,000 feet?
- Is there enough justification to waiver the 3 nm IFR separation standard?

Although these procedures were not adopted they provide a strong first step toward development of a GPS based navigational route structure throughout N90 congested airspace. For the time being, the GPS non-airway routes must meet the criteria established by the FAA National Flight Procedures Office, AVN-100. These criteria use a VOR/DME based system that requires notably larger lateral dimensions in constructing an airway. Considering the congested airspace, this increase in lateral dimensions virtually eliminates any possibility of developing alternate routes.

2.4 Newark International (EWR)

2.4.1 Airport Configuration

The EWR Airport is configured with a basic runway design that provides two primary north-south runways (04R-22L and 04L-22R) and one east–west runway (11-29). With the exception of runway 29, all other runways have a published SIAP that provides both a precision and non-precision capability. Radar approach and departure control services are provided continuously throughout the terminal area. In addition, EWR has an on-field helipad located in the vicinity of the west parking area on taxiway Juliet-Bravo. Figure 2.4.1 - 1 depicts the EWR airport layout.

2.4.1.1 Controlled/Uncontrolled Airspace

ATC service at EWR is provided by an on-airport ATCT and the N90 TRACON. The EWR airspace is contained within the N90 Class B airspace. The actual dimensions, both vertical and lateral, vary to accommodate all published instrument procedures in and out of the airport. The core of the EWR airspace extends from the surface up to and including 7,000 feet within 4 nm of the airport. Outlying levels also extend up to 7,000 feet, but their base elevations vary to control arrival, departure, and transient aircraft within the designated airspace. Certain airspace borders to the south have been tailored to ensure instrument procedures are contained within that portion of the Class B airspace that supports EWR.

To provide radar services the EWR airspace is further delegated for control purposes. Figure 2.4.1.1 - 1 is the EWR airspace delegation and Table 2.4.1.1 – 1 provides conditional and unconditional altitude use.

2.4.1.2 Air Traffic Control Handoff Points

The EWR airspace has a number of handoff points that are commonly used by both rotary- and fixed-wing air traffic. Figure 2.4.1.2 - 1, Figure 2.4.1.2 - 2, Figure 2.4.1.2 - 3, Figure 2.4.1.2 - 4, depict the fundamental arrival and departure flows for a southwesterly and northwesterly flow, based on runway configuration at EWR.

2.4.1.3 Current and Proposed Operational Procedures

As part of the N90 airspace configuration it is to be expected that operations in and out of EWR are very congested and restrictive. Although some corporate rotorcraft are based at the airport and a few emergency medical service (EMS) operators do routinely operate in the area, the majority of rotorcraft air traffic is transitioning through the airspace en route to other locations. As a whole, rotorcraft operations in the EWR area have very little impact on overall IFR operations. EWR serves as an IFR/SVFR flow point for rotorcraft air traffic en

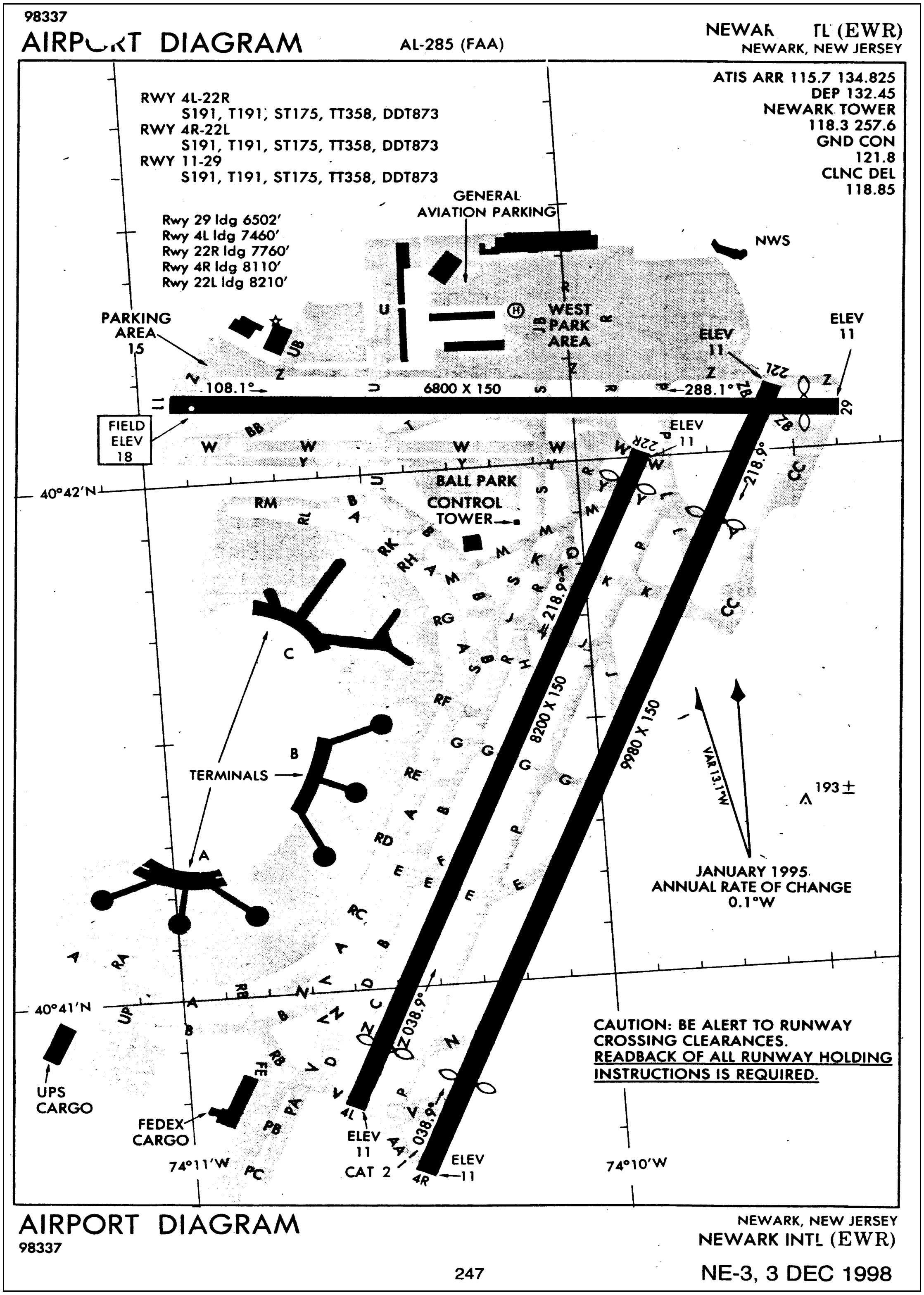

Figure 2.4.1 - 1 EWR Airport Layout

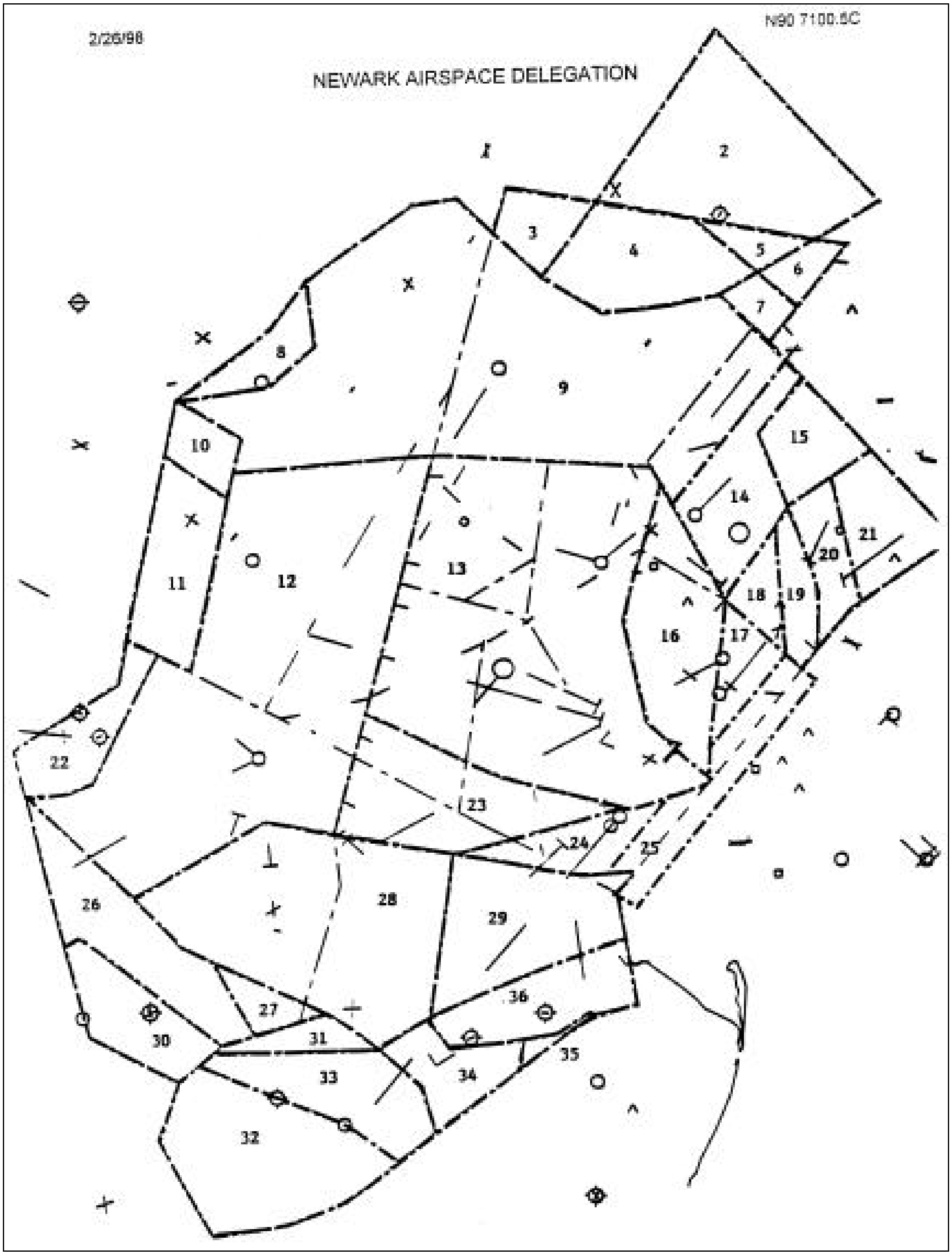

Figure 2.4.1.1 - 1 Newark Airspace Delegation

Table 2.4.1.1 - 1 Newark Conditional and Unconditional Altitude Use

Area	Unconditional	Conditional
1	6,000 feet and 7,000 feet	None
2	6,000 feet	None
3	5,000 feet/below	None
4	6,000 feet/below	None
5	6,000 feet	None
6	None	None
7	5,000 feet/below	None
8	5,000 feet/below	None
9	7,000 feet/below	None
10	6,000 feet/below	From highest altitude released by ZNY through 7,000 feet
11	4,000 feet/below and 6,000 feet	From highest altitude released by ZNY through 7,000 feet
12	9,000 feet/below	None
13	10,000 feet/below	None
14	6,000 feet/below	None
15	4,000 feet/below	None
16	8,000 feet/below	None
17	6,000 feet/below	None
18	6,000 feet/below	As released to LGA for ILS/DME Rwy 13 approach
19	5,000 feet/below	As released to LGA for ILS/DME Rwy 13 approach
20	2,000 feet/below	As released to LGA for ILS/DME Rwy 13 approach
21	None	2,000 feet/below as released by LGA for TEB VOR Rwy 24
22	9,000 feet/6,000 feet	None
23	10,000 feet/below	11, 000 feet when departing Rwys 22 R/L
24	6,000 feet/below	10,000 feet/7,000 feet when departing Rwys 22 R/L
25	2,500 feet/below	As noted in manual
26	9,000 feet/5,000 feet	None
27	8,000 feet/below	None
28	8,000 feet/below	None
29	6,000 feet/below	None
30	None	From highest altitude released by ZDC through 7,000 feet
31	8,000 feet/7,000 feet	6,000 as per WRI LOA
32	7,000 feet	None
33	7,000 feet	6,000 as per WRI LOA
34	8,000 feet/3,000 feet	None
35	4,000 feet/3,000 feet	None
36	6,000 feet/3,000 feet	None

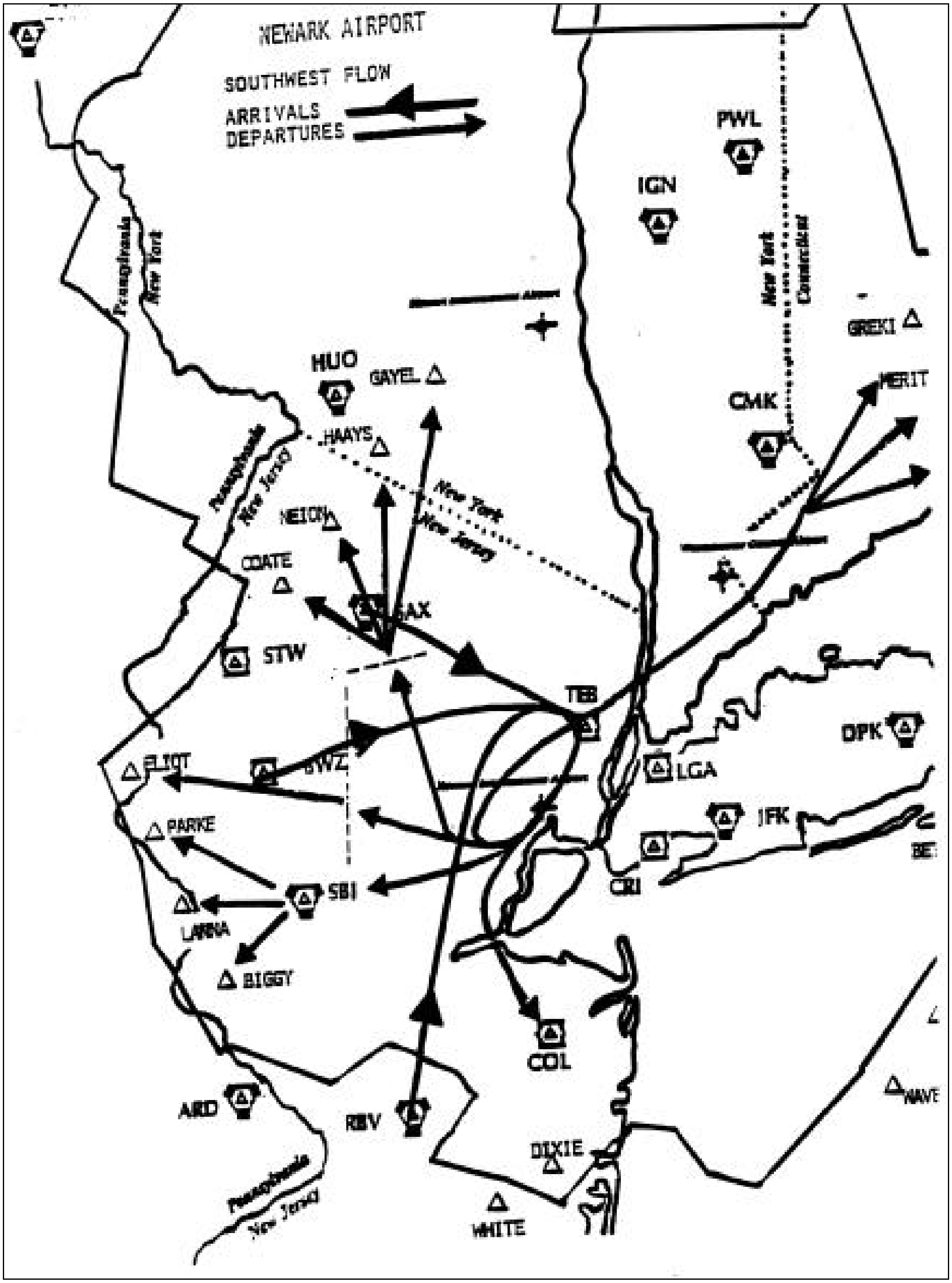

Figure 2.4.1.2 - 1 Newark Airport Southwest Flow

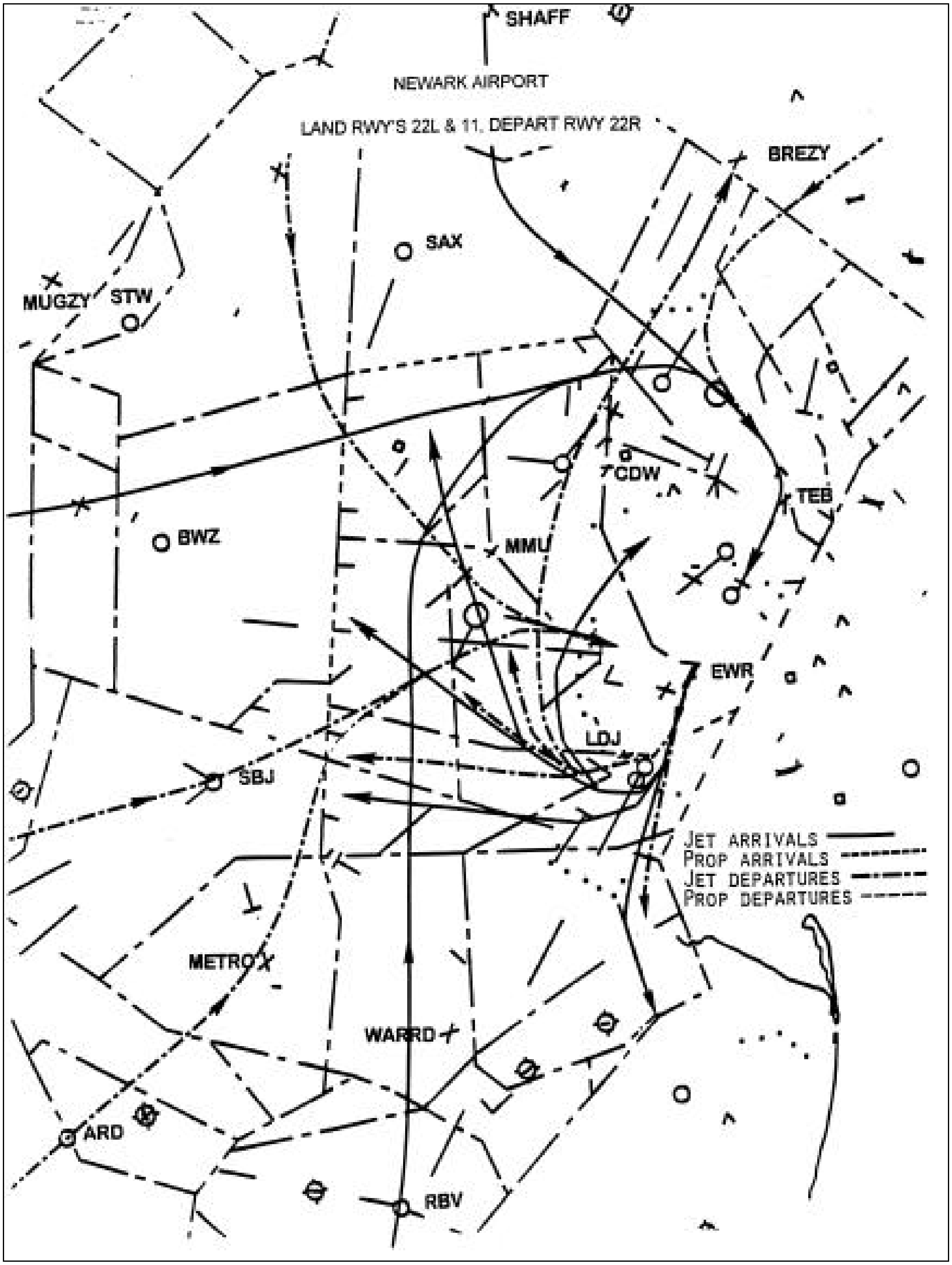

Figure 2.4.1.2 - 2 Newark Airport Landing Rwys 22L/11 and Departing Rwy 22R

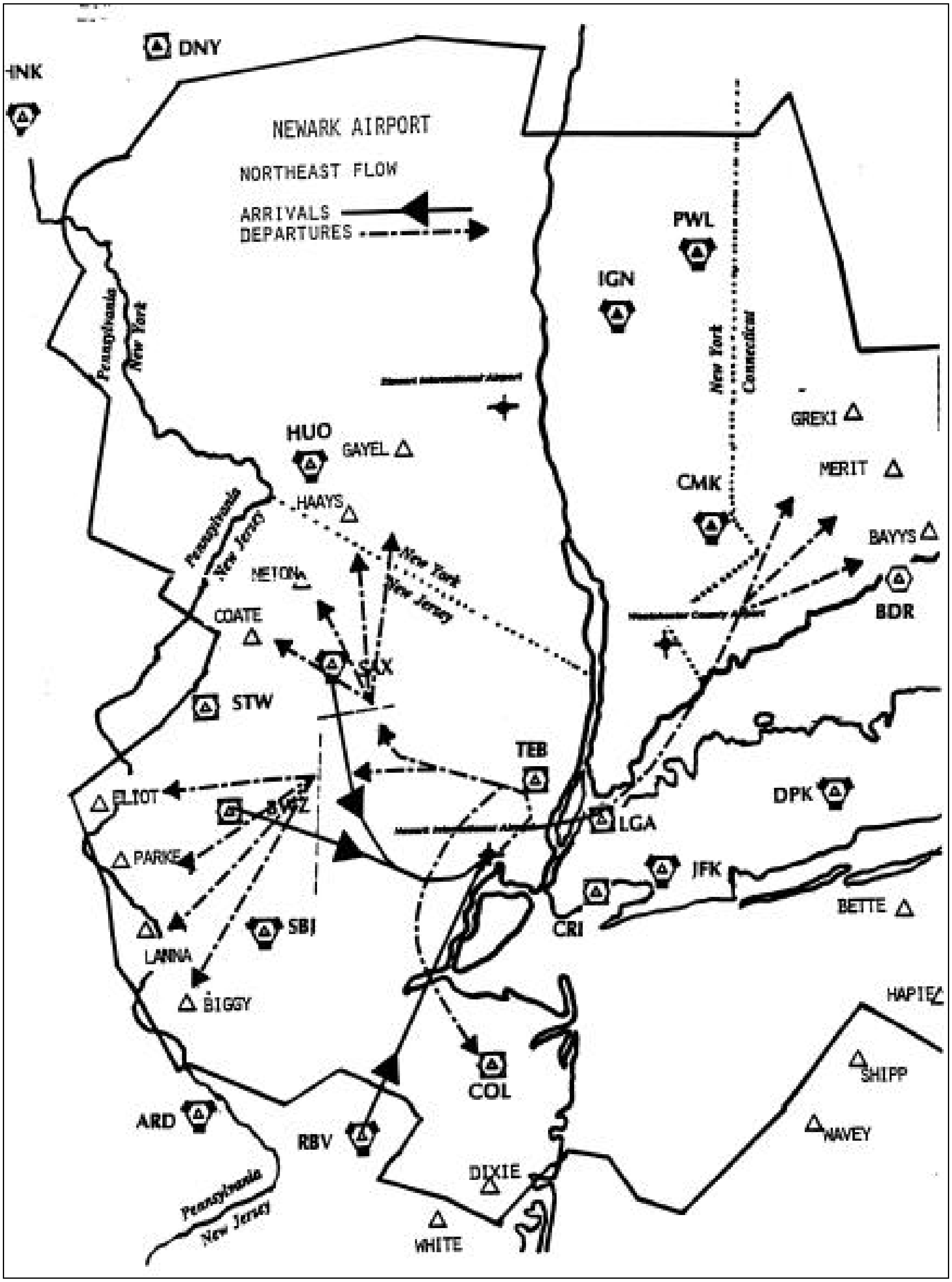

Figure 2.4.1.2 - 3 Newark Airport Northeast Flow

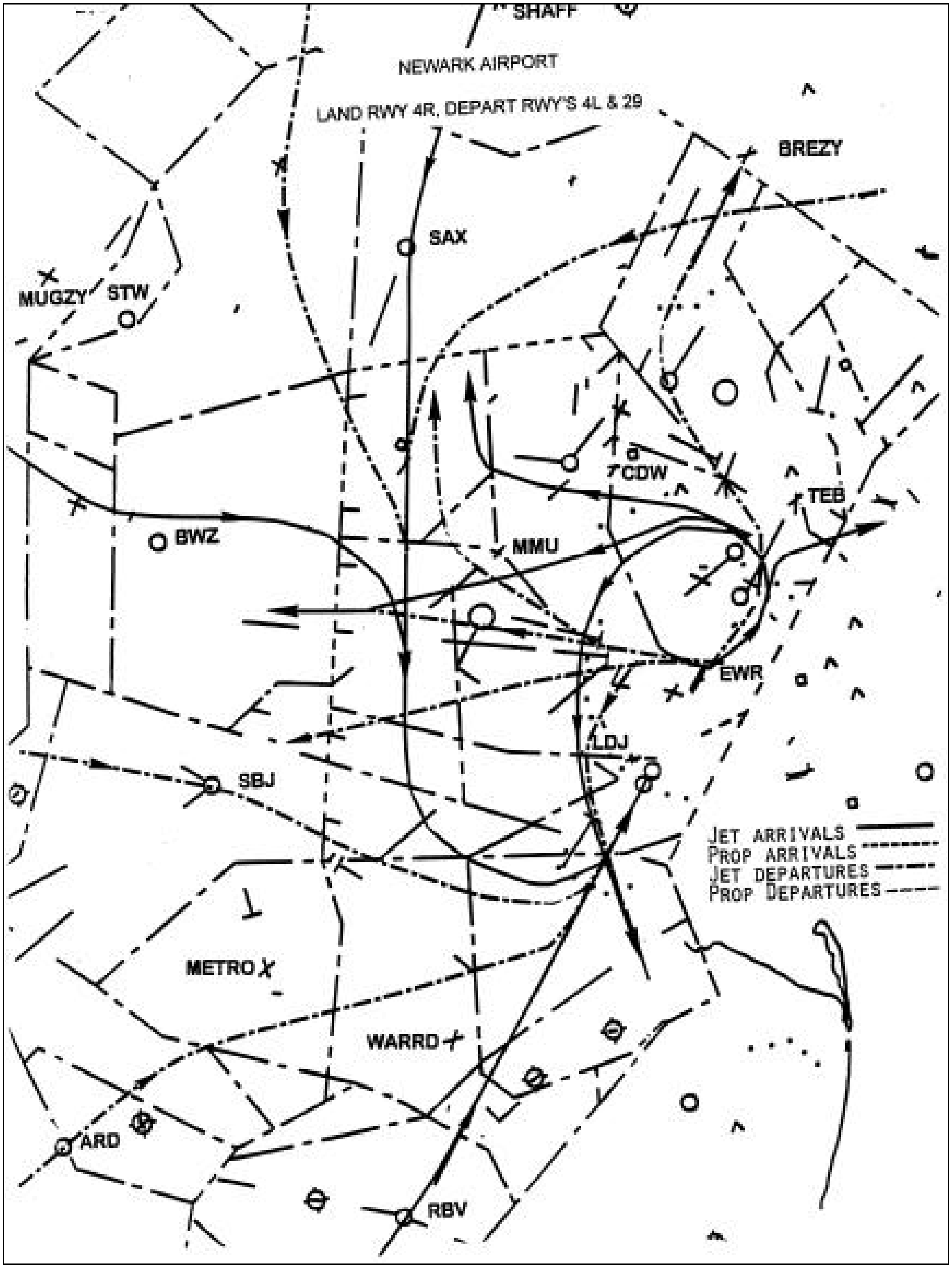

Figure 2.4.1.2 - 4 Newark Airport Landing Rwy 4R and Departing Rwys 4L/29

route to the many heliports located in and around the island of Manhattan. When weather is IMC rotorcraft traffic en route to the EWR area will normally execute an ILS approach to either runways 4L or 22L or be vectored to runway 29 for an opposite direction visual approach that transitions to the helipad.

Ghosting, the process of computer generating a simultaneous parallel target, is routinely used to substantially reduce in-trail separation when dual runway procedures are in effect. This allows the controller to tighten sequencing flows and minimize delays normally associated with IFR operations. Depending on their destination, as the rotorcraft traffic breaks-out of the weather it will either transition to land at EWR or proceed SVFR to one of the other heliports or landing sites in the immediate vicinity of Manhattan.

Unlike the PHL environment, EWR maintains an active LOA that addresses specific procedures in support of SVFR. This agreement requires strict adherence and is signed by both the EWR ATCT manager and a representative of the organization or company requesting the SVFR authorization. The LOA requires each participant to maintain visual separation with reference to the surface, with air traffic in the airport traffic patterns, along routes, and at reporting/holding points. Compliance by the signatories allows the tower to apply reduced SVFR separation, thereby enhancing local operability in the terminal Class B airspace under SVFR. This ensures that appropriate separation is maintained with other SVFR helicopters and IFR fixed-wing aircraft that may be operating in the local area. Not having signed the LOA does not eliminate the SVFR option, but may impede obtaining a clearance and limit certain procedural options.

2.4.1.4 Current Published IFR Procedures

Except for runway 29, all EWR runways have a published SIAP that includes a precision capability. Runway 29 has neither precision nor non-precision capability (section 2.4.1). The approaches to runways 4L and 22L also provides a “Copter ILS” procedure. The copter approach provides a significant reduction in both ceiling and visibility for rotorcraft operations in IMC. The ceiling is reduced 100 feet and visibility is decreased to one quarter mile. Table 2.4.1.4 - 1 is a complete list of all current available instrument procedures at the EWR.

Table 2.4.1.4 - 1 EWR Instrument Procedures

Type Procedure	Runway/Designation	Type Procedure	Runway/Designation
STARS	Helon One	SIAPs	ILS Rwy 4R (Cat II)
	Owbie One (FMS)		ILS Rwy 4R (Cat III)
	Penns One		VOR/DME or GPS Rwy 22 L&R
	Robbinsville One		VOR Rwy 11
	Shaff One		NDB or GPS Rwy 4L
	Williamsport One		NDB or GPS Rwy 4R
	Yardley Two		GPS Rwy 11
SIAPs	ILS Rwy 4L		Copter ILS/DME Rwy 4L
	ILS Rwy 4R		Copter ILS/DME Rwy 22L
	ILS Rwy 11	Departure	Arthur Kill Two (Vector)
	ILS Rwy 22L		Mariner One (Vector)
	ILS Rwy 22R		Newark Six (Vector)

2.4.2 Ground Handling Procedures

As with PHL, EWR has no special ground handling procedures for rotorcraft. The primary heliport is located in the west parking area near the GA terminal. On approach, once the airport is in sight, rotorcraft from the north can transition directly to the helipad. Those rotorcraft on approach from the south normally transition to a taxiway and proceed via a ground route to the GA area. Occasionally, the ILS critical area does restrict some rotorcraft ground taxing while aircraft are on approach, but these circumstances are infrequent.

Figure 2.4.2 - 1 shows the navigational aids critical areas on EWR. Considering that five of the six runways have an ILS, the ground area is inundated with potential taxi restrictions that could limit rotorcraft ground taxi operations during certain weather conditions.

2.5 Teterboro Airport (TEB)

2.5.1 Airport Configuration

The TEB Airport is configured with a basic runway design that provides one north-south runway (1-19) and one northeast-southwest runway (6-24). With the exception of runway 1 all other runways have a published SIAP. Runway 6 is the only runway that is supported by both a precision and non-precision capability. Teterboro is a very noise sensitive area. The airport has a published noise abatement procedure for both rotary- and fixed-wing aircraft and requires strict adherence. Figure 2.5.1 - 1 depicts the TEB airport layout.

2.5.1.1 Controlled/Uncontrolled Airspace

ATC services at TEB, like EWR, are provided by an on-airport ATCT and the N90 TRACON. The TEB airspace is contained beneath the floor of the N90 airspace and is designated as Class D airspace. Its dimensions, both vertical and lateral, extend from the center of the airport out 5 nm, and up to and including 1,800 feet from the surface. The TEB airspace is bordered on the east by the LGA Class B airspace and on the south by the EWR Class B airspace. The area is congested as it is wedged between two extremely busy airports. Approach/departure air traffic at both LGA and EWR can be observed from the TEB control tower.

2.5.1.2 Air Traffic Control Handoff Points

Due to LGA to the east and EWR to the south, a number of handoff points are commonly used by both rotary- and fixed-wing air traffic. The arrival and departure procedures for runways 19 and 24 are run in concert with the southwest flow pattern at EWR, while arrival and departure procedures for runways 1 and 6 are paired with the northeast flow pattern at EWR. The basic instrument arrival and departure flows at TEB, based on runway configuration and directional flow at EWR are depicted in Figure 2.5.1.2 - 1 and Figure 2.5.1.2 - 2.

2.5.1.3 Current and Proposed Operational Procedures

According to the TEB ATC facility manager there is a high concentration of rotorcraft traffic that operates in the area, the majority of which operates VFR. In addition, TEB, like EWR has a separate SVFR LOA that provides reduced separation for those who have signed it. TEB is also directly linked to the TEC program that provides dedicated IFR routes between airports. The only available “dedicated” SIAP for rotorcraft is the “Copter ILS”.

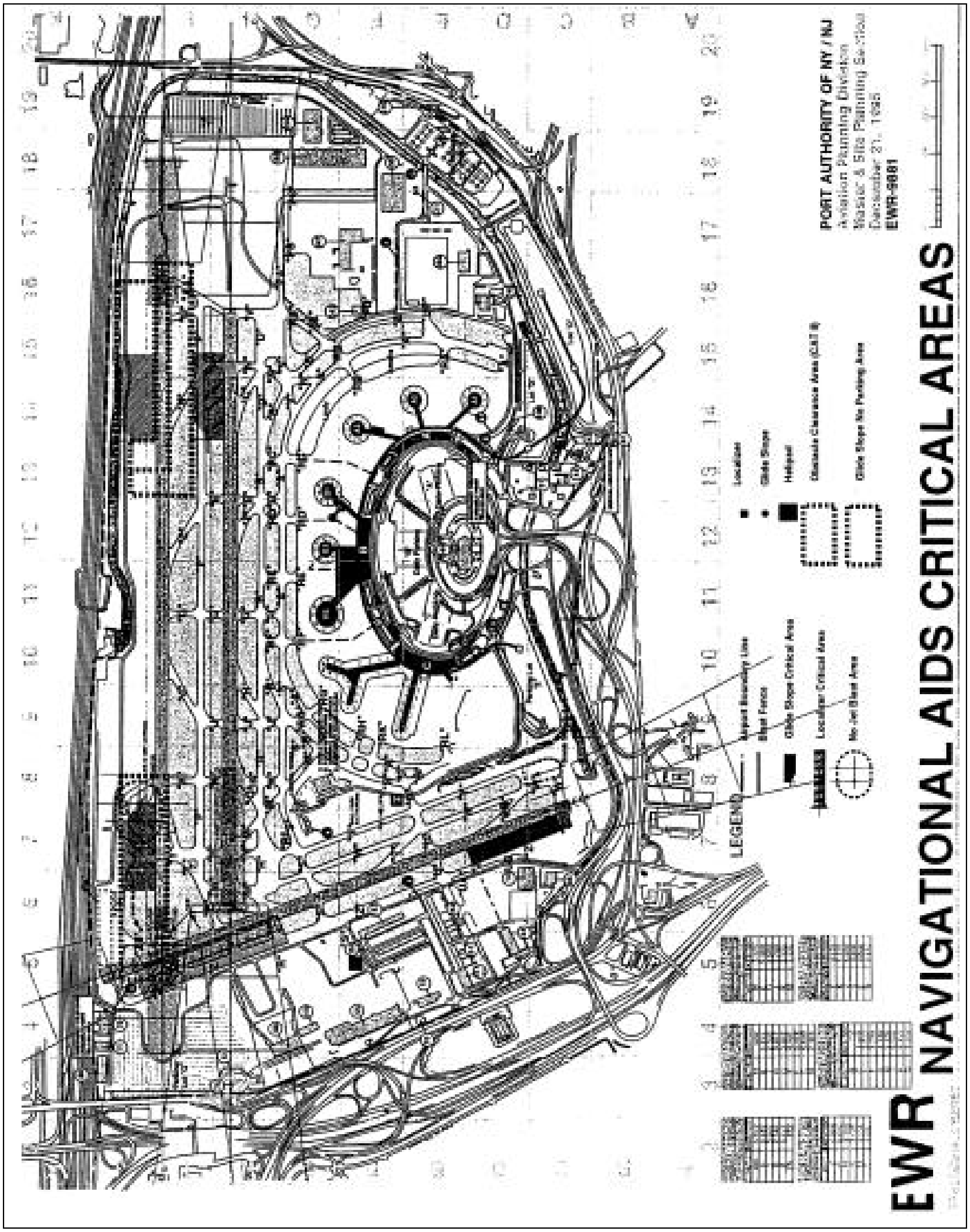

Figure 2.4.2 - 1 Navigational Aids Critical Areas

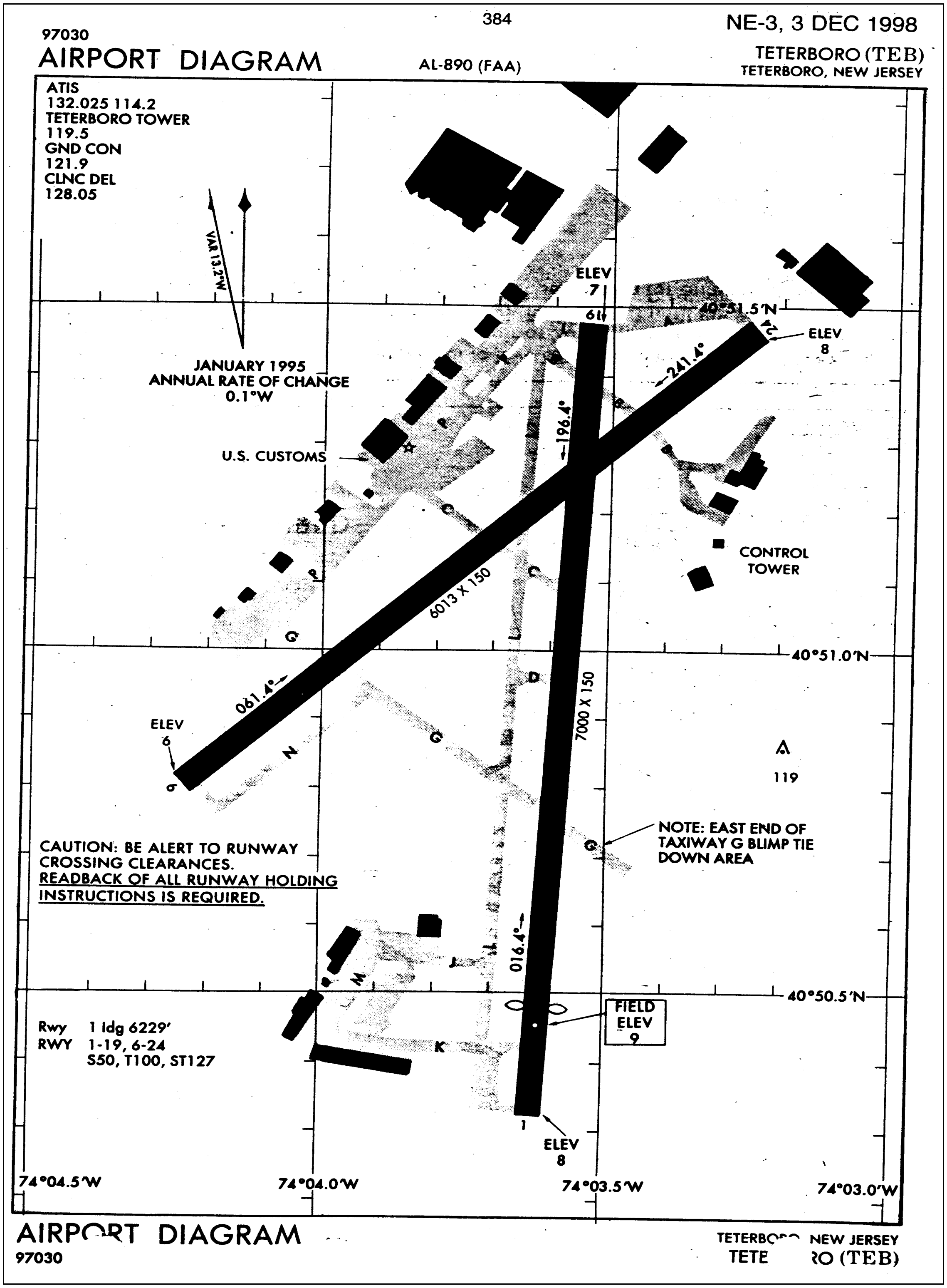

Figure 2.5.1 - 1 Teterboro (TEB) Airport Layout

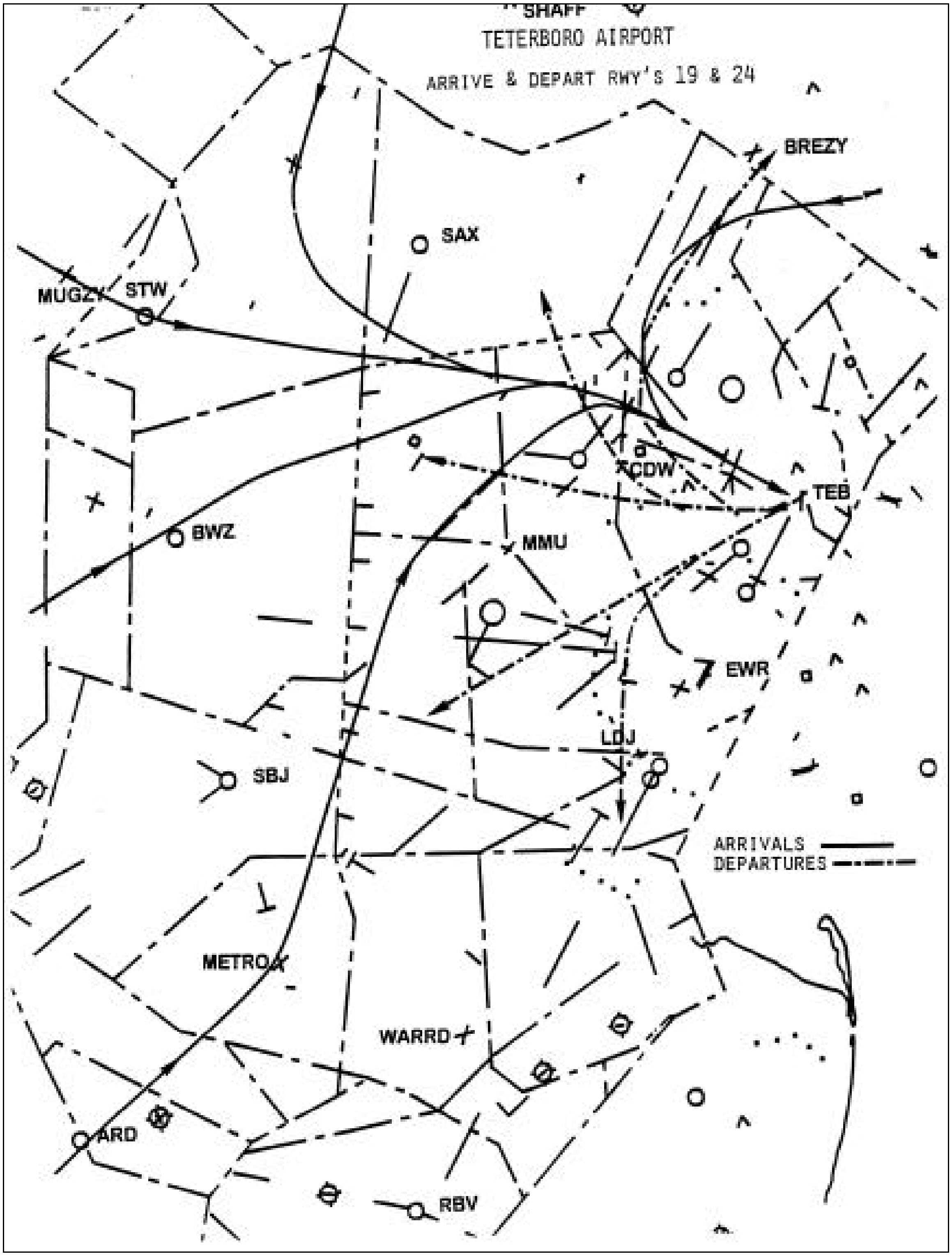

Figure 2.5.1.2 - 1 Teterboro Airport Arrival/Departure Rwy 19 and Rwy 24

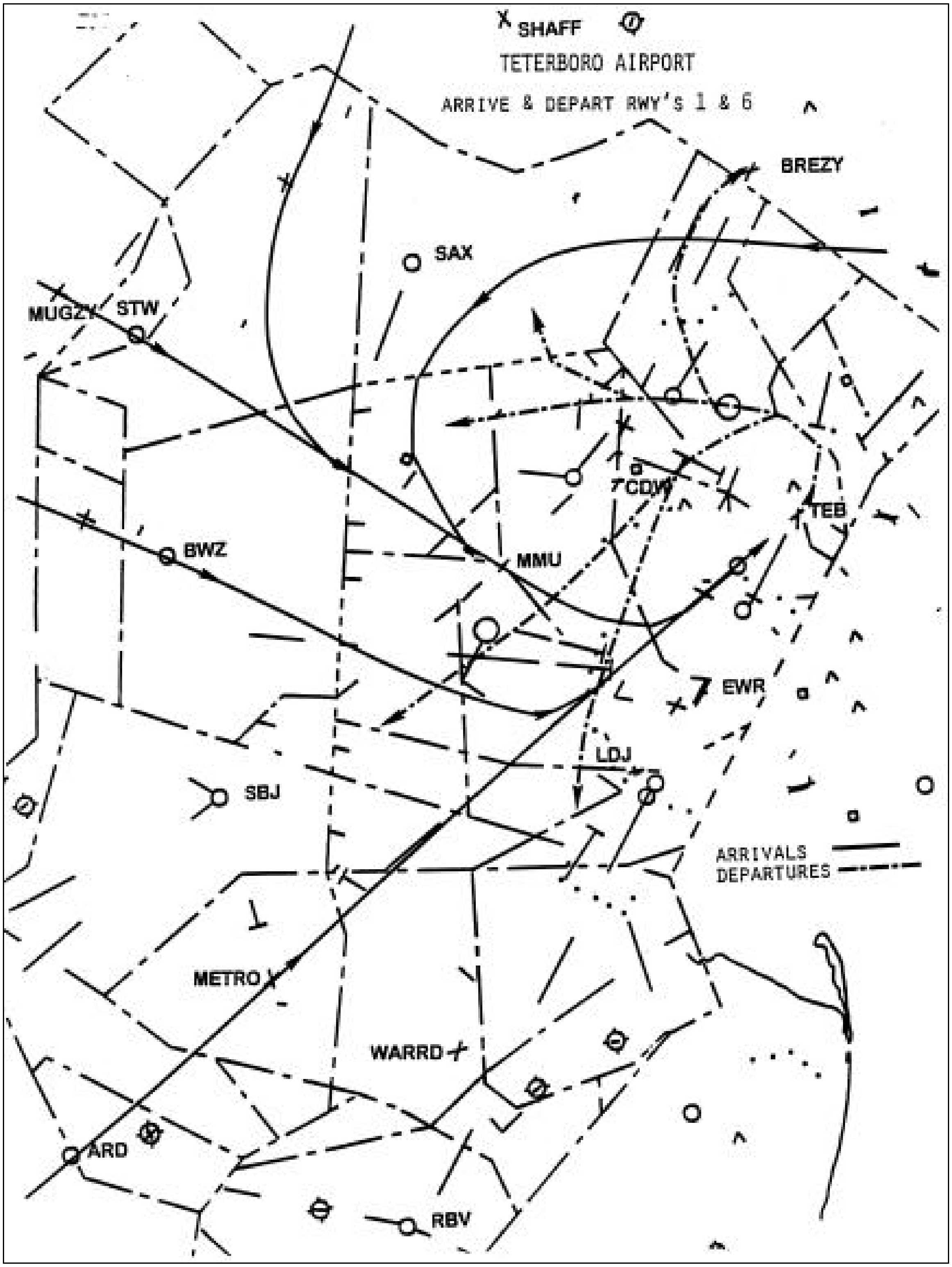

Figure 2.5.1.2 - 2 Teterboro Airport Arrival/Departure Rwy 1 and Rwy 6

The primary issue at TEB is noise abatement. Since early 1970, TEB has had some form of noise abatement procedure in place. Throughout the years different monitoring systems have been installed, but the main effort has been generated by the local community to find a working relationship with the airport. The current system was commissioned in September 1987 by Congressman Robert Torricelli and members of what would become the Teterboro Aircraft Noise Abatement Committee (TANAAC). The TANAAC remains very active. As a result, the TEB has a published noise abatement procedure for both rotary- and fixed-wing aircraft operating at the airport that provides specific operational recommendations. Violation of these procedures could ultimately result in the offending aircraft being barred from operating at TEB.

2.5.1.4 Current Published IFR Procedures

The TEB SIAPs are configured to support runways 6 and 24. A precision approach capability is only provided to runway 6, which supports both standard and “Copter ILS” procedures. The copter approach reduces both ceiling and visibility for rotorcraft operations in IMC. The ceiling is reduced 100 feet and visibility decreased to one quarter mile. Table 2.5.1.4 - 1 is a complete list of all current available instrument procedures at the TEB.

Table 2.5.1.4 - 1 TEB Instrument Procedures

Type Procedure	Runway/Designation	Type Procedure	Runway/Designation
STARS	Metro Four	SIAPs	VOR/DME Rwy 6
	Penns One		VOR Rwy 24
	Wilkes Barre Three		NDB or GPS Rwy 6
	Yardley Two		GPS Rwy 24
SIAPs	ILS Rwy 6		Copter ILS Rwy 6
	VOR/DME or GPS-A	Departure	Teterboro Four (Vector)
	VOR/DME or GPS-B		
	VOR/DME RNAV Rwy 24		

2.5.2 Ground Handling Procedures

The airport ground configuration at TEB is not complicated and does not require any specific ground handling procedures other than control instruction from the ground controller. For the most part, the airport serves as a base for a variety of national corporations and a number of fixed base operators (FBO). The crews that pilot these aircraft are very familiar with the airport and ground taxi routes. Consequently, no specific ground handling procedures have been developed for TEB.

2.6 LaGuardia (LGA)

2.6.1 Airport Configuration

LGA Airport is configured with a basic runway design that provides two primary runways. One aligned for a northeast-southwest flow (4-22) and the other with a southeast–northwest flow (13-31). With the exception of runway 31 all runways have a published SIAP that provides precision and non-precision capability. Radar approach and departure control services are provided continuously throughout the terminal area. In addition, LGA has two on-field helipads located in vicinity of the GA terminal on the east side of the airport. Figure 2.6.1 - 1 depicts the LGA airport layout.

2.6.1.1 Controlled/Uncontrolled Airspace

As with EWR, LGA airspace is contained within the N90 Class B airspace and provides ATC services through an on-airport ATCT and the N90 TRACON. The actual vertical and lateral dimensions vary to accommodate all published instrument procedures in and out of the airport. The core of the LGA airspace extends from the surface up to and including 7,000 feet within approximately 5 nm for the airport. Outlying levels also extend up to 7,000 feet, but their base elevations vary to control arrival, departure, and transient aircraft within the designated airspace. Certain airspace borders to the south have been tailored to incorporate instrument procedures for JFK International Airport.

For radar services the LGA airspace is further delegated for control purposes. Figure 2.6.1.1 - 1 presents the LGA airspace delegation and Table 2.6.1.1 – 1 provides the conditional and unconditional altitude use.

2.6.1.2 Air Traffic Control Handoff Points

ATC services at LGA are provided by an on-airport ATCT and the N90 TRACON. The airspace has a number of handoff points that are commonly used by both rotary- and fixed-wing air traffic. Figure 2.6.1.2 - 1, Figure 2.6.1.2 - 2, Figure 2.6.1.2 - 3, and Figure 2.6.1.2 - 4 depict the fundamental arrival and departure flows for a southwesterly and northwesterly flow, based on runway configuration at LGA.

2.6.1.3 Current and Proposed Operational Procedures

LGA experiences a high volume of both rotary- and fixed-wing air traffic as part of the N90 airspace configuration. Of all the airports involved in this investigation, LGA has the highest level of rotorcraft activity including both VFR and IFR operations. Most of the rotorcraft that enter the LGA airspace are transitioning to another facility, normally one of the heliports located in and around the island of Manhattan. For IFR rotorcraft landing at LGA there is a well-regulated routine for the rotorcraft to execute an ILS approach to either runway 13 or 22. Once the airport is in sight, the aircraft can either proceed to the on-airport heliport or via SVFR to its final destination within the LGA airspace. LGA, like both EWR and TEB, has an SVFR LOA that provides reduced separation for those who signed it. These agreements are similar in nature (Sections 2.4.1.3 and 2.5.13) and provide the same level of access to all signatories. In actuality, LGA serves as the northern entry point for the Manhattan Heliports, while EWR serves as the southern entry point. From discussions with the controllers at both airports, LGA handles a high volume of through traffic that is making this Manhattan heliport transition. As a result, working the IFR rotorcraft traffic in and out of the area is more involved and a certain level of delay routinely occurs. However, pilots have a different perspective on the IFR situation at LGA; they have relatively few problems with the IFR system and feel that it is adequate (section 2.7).

Of those rotorcraft that do land at LGA, the majority transition and proceed directly to the heliport in the GA area on the east side of the airport. The intersecting runway configuration makes separation of aircraft even more critical and requires continual monitoring beyond that of other study airports that offer parallel or simultaneous runway arrangement. The close proximity of aircraft landing on one, and departing on another runway that actually intersect, requires a heightened level of awareness to ensure proper spacing and sequencing.

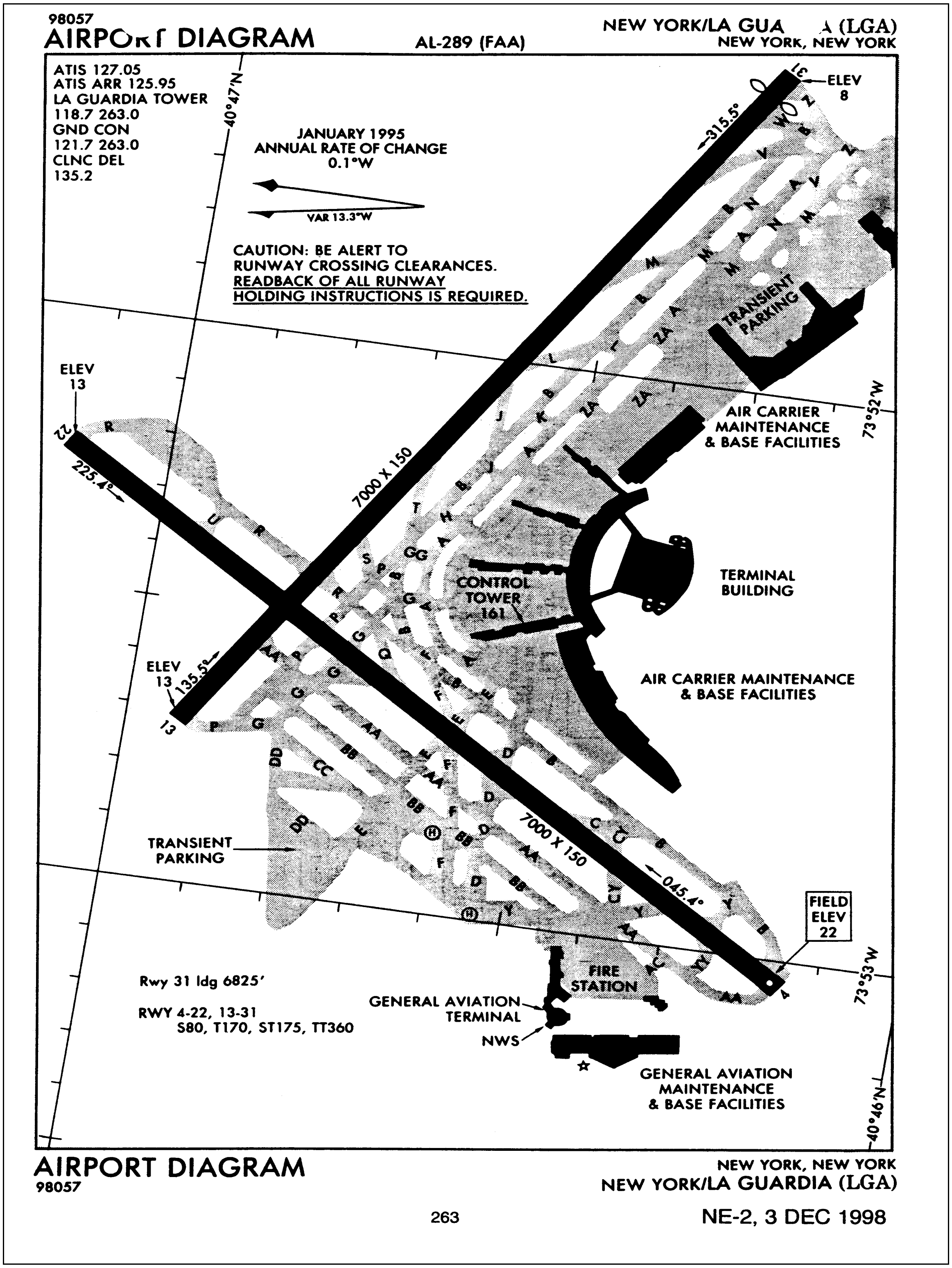

Figure 2.6.1 - 1 LaGuardia (LGA) Airport Layout

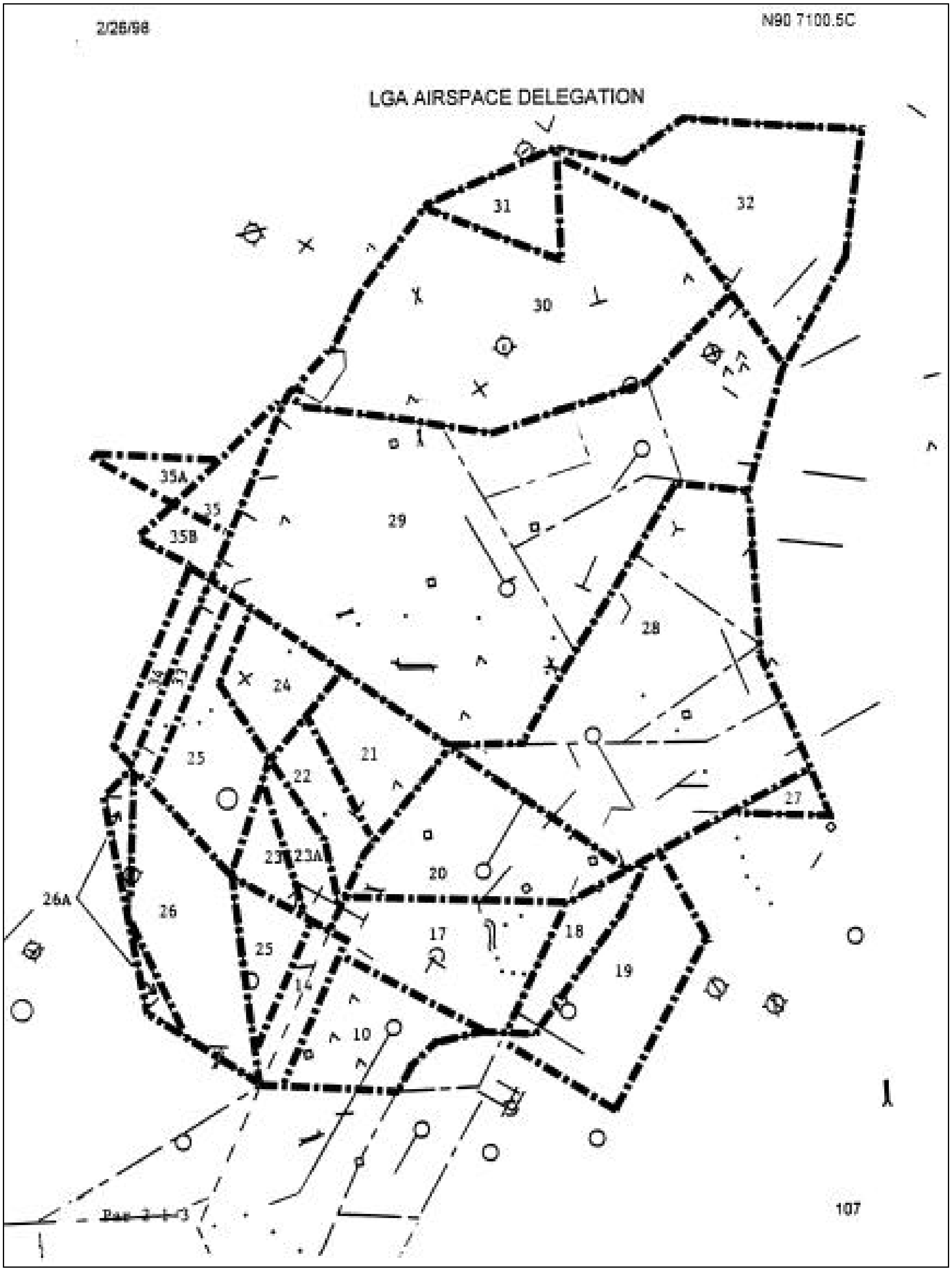

Figure 2.6.1.1 - 1 LaGuardia Airspace Delegation

Table 2.6.1.1 - 1 LGA Conditional and Unconditional Airspace Use

Area	Unconditional	Conditional
1	None	11,000 feet/10,000 feet for arrival via LIZZI
1A	None	10,000 feet for arrival via LIZZI
2	10,000 feet	None
3	11,000 feet/10,000 feet	None
4	13,000 feet/10,000 feet	None
5	13,000 feet/9,000 feet	None
6	11,000 feet/9,000 feet	None
7	11,000 feet/7,000 feet	None
8	None	10,000 feet/7,000 feet when EWR is not departing Rwys 22L/R and as noted in N90 7100.5C
9	10,000 feet/Below	10,000 feet/4,000 feet when released to JFK for ILS Rwy 13L approaches and as noted in N90 7100.5C
10	12,000 feet/below	12,000 feet/4,000 feet when released to JFK for ILS Rwy 13L approaches
11	None	12,000 feet/1,500 feet when released by JFK for Maspeth/Coney climbs
12	None	10,000 feet/2,500 feet when released by JFK for Coney climbs
13	None	5,000 feet/4,000 feet when released by JFK for Coney climbs
14	12,000 feet/3,500 feet	12,000 feet/4,000 feet when released to JFK for ILS Rwy 13L approaches
15	10,000 feet/3,500 feet	10,000 feet/4,000 feet when released to JFK for ILS Rwy 13L approaches as noted in N90 7100.5C
16	10,000 feet/3,500	As noted in N90 7100.5C
17	12,000 feet/below	None
18	12,000 feet/below	12,000 feet/4,000 feet when released to JFK for Rwy 22L/R approaches
19	None	3,000 feet/1,000 feet when released to JFK for Rwy 31 LOC approaches
20	15,000 feet/below	None
21	15,000 feet/below	15,000 feet/3,000 feet when released to EWR for TEB VOR Rwy 24 approaches
22	15,000 feet/3,000 feet	2,000 feet/1,800 feet when released to EWR for LGA Rwy 13 ILS approaches
23	15,000 feet/7,000 feet	3,000 feet/2,700 feet or 2,000 feet/1,800 feet when released to EWR for LGA Rwy 13 ILS/DME approaches
23A	15,000 feet/6,000 feet	3,000 feet/2,700 feet or 2,000 feet/1,800 feet when released to EWR for LGA Rwy 13 ILS/DME approaches
24	15,000 feet/5,000 feet	None
25	15,000 feet/7,000 feet	None
26	15,000 feet/9,000 feet	None
26A	15,000 feet/11,000 feet	None
27	6,000 feet/below	None
28	10,000 feet/below	None
29	11,000 feet/below	None
30	5,000 feet/below	None
31	5,000 feet/below	5,000 feet when released to LIB for N69 approaches/departures
32	3,000 feet/below	None
33	15,000 feet/8,000 feet	None
34	8,000 feet	None
35	7,000 feet/5,000 feet	None
35A	5,000 feet	None
36	7,000 feet/6,000 feet	None

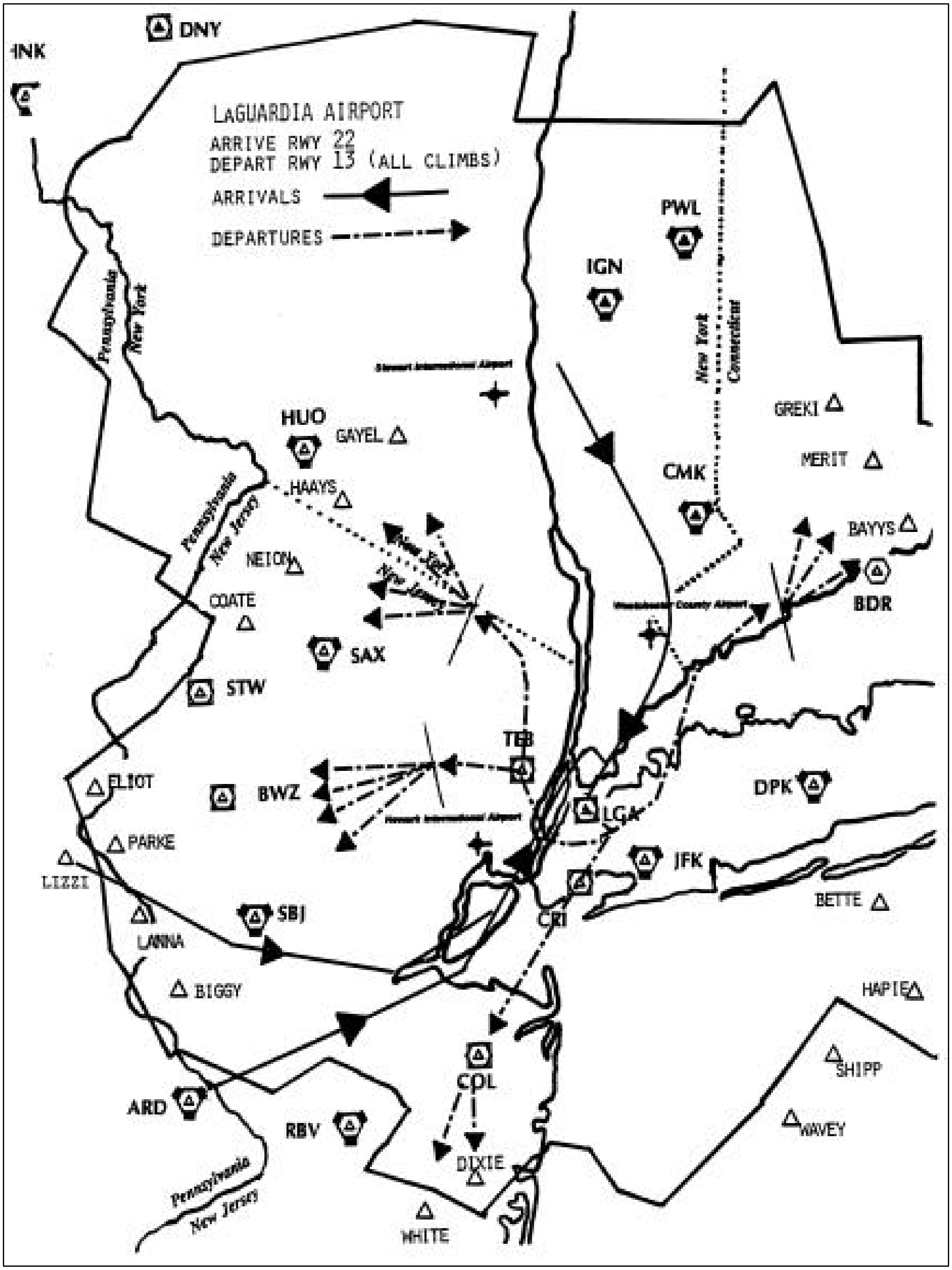

Figure 2.6.1.2 - 1 LaGuardia Airport Overview Landing Rwy 22 and Departing Rwy 13 (all climbs)

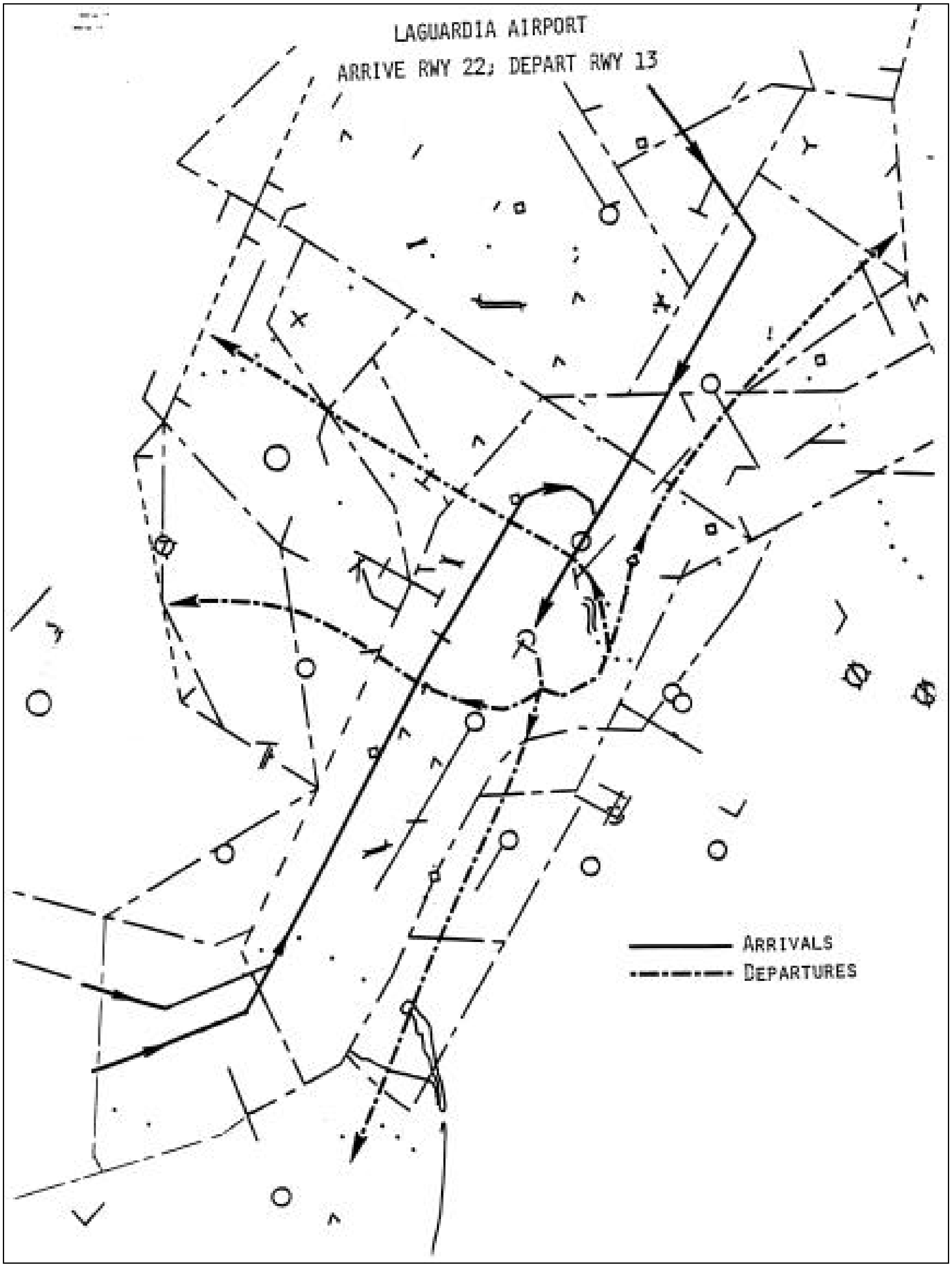

Figure 2.6.1.2 - 2 LaGuardia Airport Landing Rwy 22 and Departing Rwy 13

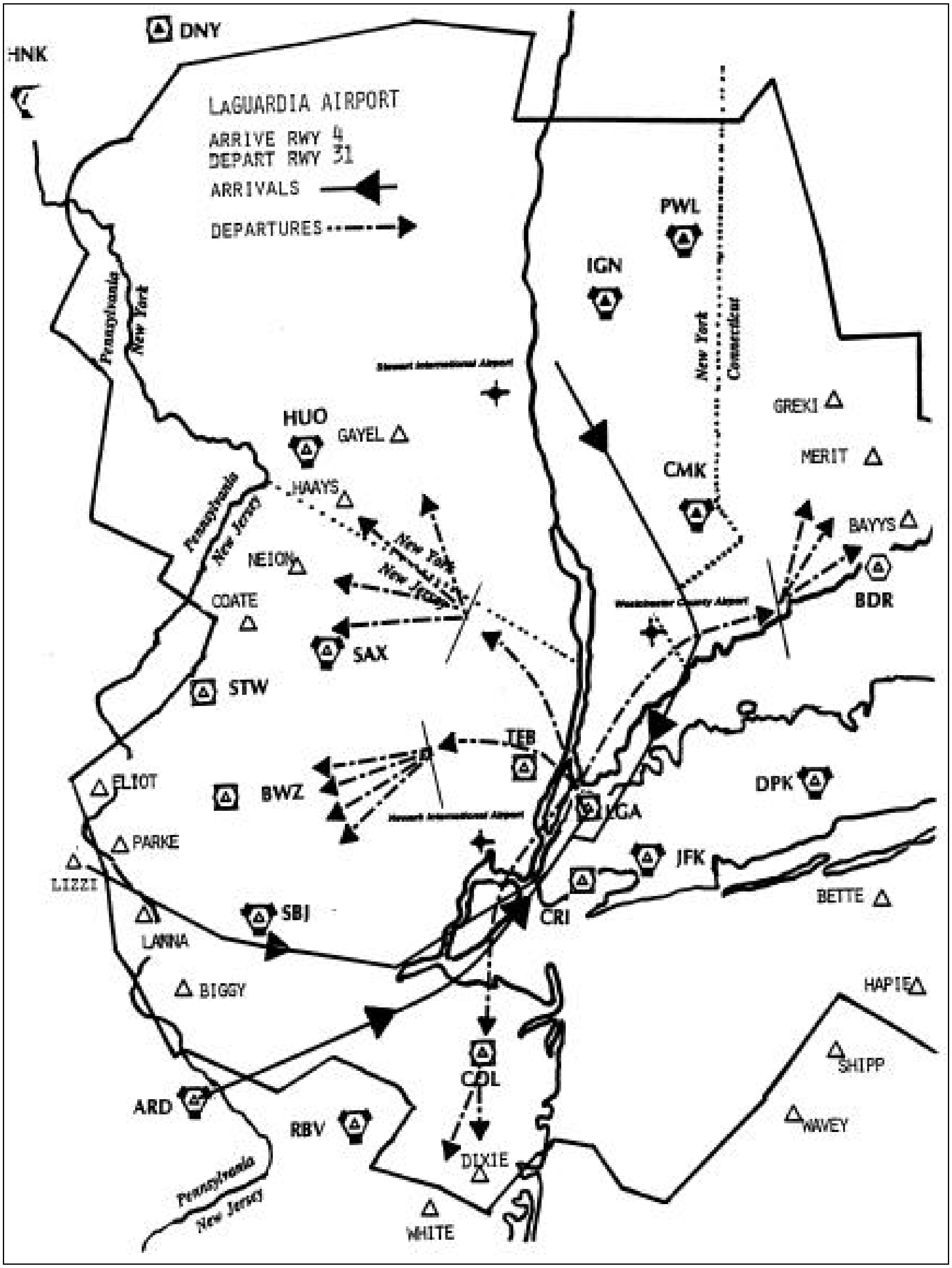

Figure 2.6.1.2 - 3 LaGuardia Airport Overview Landing Rwy 4/Departing Rwy 31

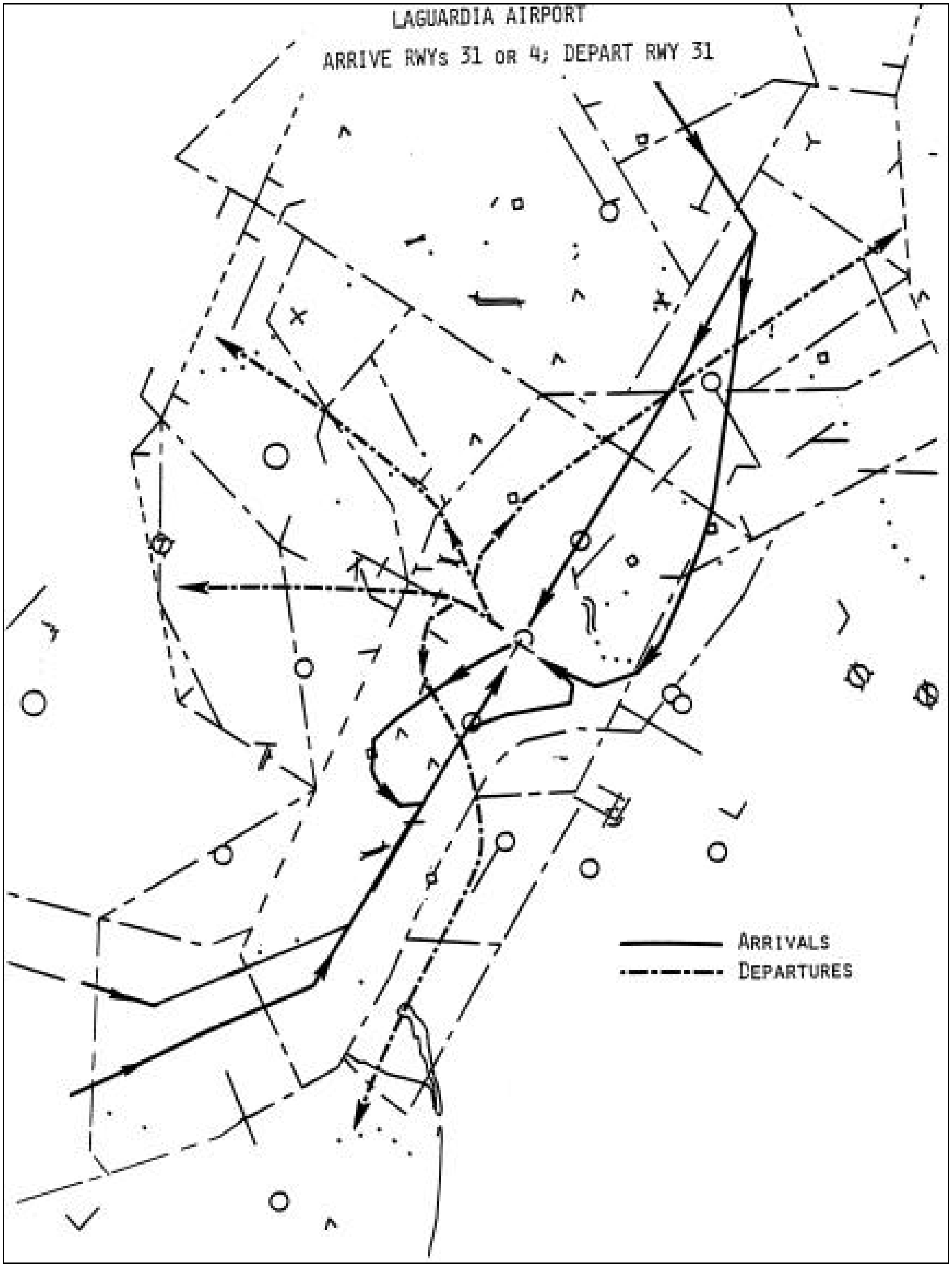

Figure 2.6.1.2 - 4 LaGuardia Airport Landing Rwys 4/31 and Departing Rwy 31

As with EWR, the LGA arrival and departure routes are very detailed and allow virtually no room for deviation in spacing and sequencing standards. In trying to provide rotorcraft with an alternate instrument approach procedure the issue of protected airspace becomes a major concern. Missed approach airspace cannot overlap for obvious reasons, but in a highly active ATC environment that provides multiple approach and departure paths, it is extremely difficult, if not impossible, to introduce a new procedure that would not conflict with existing procedures. Another issue for the LGA area is that even though approaches from the north are over water, the corridor is not unobstructed. There are a number of ground obstacles in close to the east side of the airport where the heliport and GA terminal are located that could have a detrimental effect on the development of any offset or PinS instrument approach.

Noise is one element of rotorcraft operation that continually arises. The existence of rotorcraft in the community appears to translate into noise complaints despite the many efforts to minimize its effect. With the high level of rotorcraft activity in the vicinity of LGA, noise complaints play an ever-increasing role in where rotorcraft can operate both VFR and IFR. As with TEB, LGA is very sensitive to the community and the noise issue is an important item. The development of any SNI procedure will entail flight at low altitudes and, aside from the issue of obstacle clearance and separation between other aircraft, noise could ultimately be the driving factor.

In the mid-1980's in an effort to better control rotorcraft VFR activity, the FAA in conjunction with metropolitan authorities, published a number of VFR Helicopter Route Charts. These routes, although not mandatory, prescribe altitudes and recommended routing that guide rotorcraft through congested airspace. Many ATC procedures are predicated on reporting specific points along these routes to gain access in and out of controlled airspace. The program has been a success over the years and has significantly enhanced rotorcraft operability throughout areas in which they have been published.

2.6.1.4 Current Published IFR Procedures

All runways at LGA have a published SIAP, and with the exception of runway 31, all have a precision capability. The approach to runway 22 also provides a "Copter ILS" procedure. The copter approach provides a reduction in both ceiling and visibility for rotorcraft operations in IMC. The ceiling is reduced 100 feet and visibility is lowered to one quarter mile. Table 2.6.1.4 - 1 is a complete list of all current available instrument procedures at the LGA.

Table 2.6.1.4 - 1 LGA Instrument Procedures

Type Procedure	Runway/Designation	Type Procedure	Runway/Designation
STARS	Milton One	SIAPs	VOR/DME or GPS-E
	Minks One		VOR/DME or GPS-G
	Nobbi Three		VOR/DME or GPS-H
	Rockdale Two		VOR or GPS-F
SIAPs	ILS Rwy 4		VOR Rwy 4
	ILS Rwy 13		NDB or GPS Rwy 4
	ILS Rwy 22		NDB or GPS Rwy 22
	LOC Rwy 31		Copter ILS/DME Rwy 22
	LDA-A	Departure	LaGuardia Eight (vector)

2.6.2 Ground Handling Procedures

LGA has no special ground handling procedures for rotorcraft. A heliport is located near the GA terminal on the east side of the airport. On approach, once the airport is in sight, rotorcraft can transition directly to the helipad and ground taxi to the parking or terminal area. If the weather is such that an approach to the runway is required, the rotorcraft will exit the runway and either ground or hover taxi to the appropriate parking area.

2.7 Helicopter Operator Interviews

The helicopter operators known to frequently use the four study airports were interviewed in order to gain an understanding of real world operations at these airports. Pilot's and operator's organizations, ERHC, NEHPA, MAHA, and HAI were contacted and all suggested individuals to interviews. The decision was made to interviews the pilot/operators by telephone rather than in person for two reasons. First, it was the best way to reach the highest number of interviewees. Due to their irregular hours and the on-call nature of their work, it is very difficult to arrange one time and place that will fit the schedules of a large number of pilots. Second, discussing issues on an individual level allows for more honest responses than can sometimes happen in groups due peer pressure or politics.

Twenty-one questions were developed as a guide to define the "real world" operational characteristics at the fours study airports. Of the fifty-nine pilots contacted, thirty-five provided telephone interviews. This is a response rate of fifty-nine percent, a higher percentage than written surveys or scheduled meetings often provide. A copy of the interview questions can be found in Appendix D.

With one exception, the respondents were those who would be affected by changes to the Northeast Helicopter Corridor IFR helicopter operating environment. In other words, interviewed pilots were those who perform missions that require all-weather capability, whose aircraft and crews are instrument certified, and who routinely fly IFR in the study area. Furthermore, most, 54 percent, currently operate in all or part of the Northeast Helicopter Corridor.

2.7.1 Operational Characteristics

This section discusses the typical operational profiles as flown by the pilots interviewed. It includes types of aircraft, origins and destinations, altitudes flown, and operational procedures. It also discusses decision factors under which pilots select whether or not to fly IFR, by examining the conditions and defining operational benefits and constraints.

2.7.1.1 Type Of Aircraft

The helicopters flown by interview pilots are most often larger models that support missions requiring an all-weather capability. Such missions include, but are not limited to, corporate executive, small package delivery, and some aspects of EMS—all common missions in the study area. The types of aircraft used by the interviewed pilots were Sikorsky S-76 (A through C models); Bell models 230, 222, 412 and 430; AS 350 and 355; BK 117; and McDonnell-Douglas (MD) 900. The S-76 by far is the most commonly operated. The number of each aircraft type flown by the interviewed pilots is shown in Figure 2.7.1.1 - 1.

2.7.1.2 Origins and Destinations

The study focuses on four major airports in the northeastern United States, PHL, LGA, TEB, and EWR. The majority of helicopter pilots interviewed that use these airports are based in

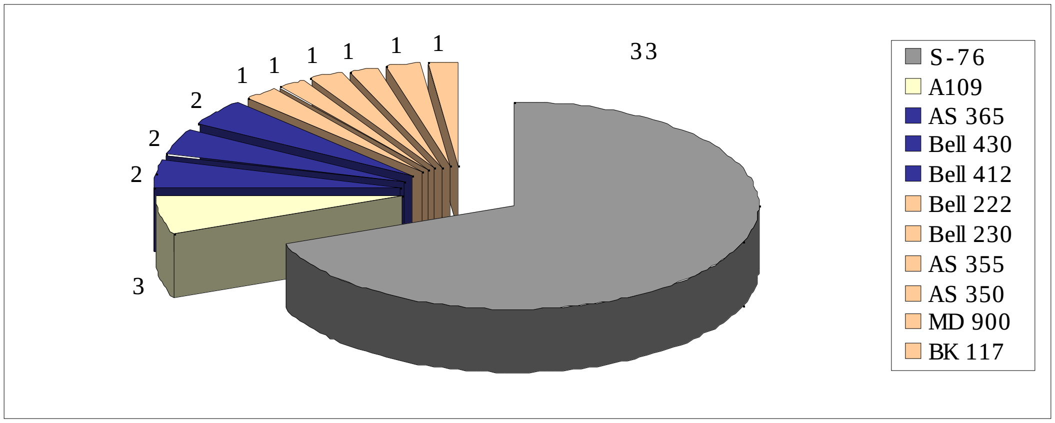

Figure 2.7.1.1 - 1 Aircraft Models

New York State, but many are based in the six nearby states in the northeast, Pennsylvania, New Jersey, Connecticut, Massachusetts, Rhode Island, and New Hampshire. The number of interviewees located in each of these states is shown Figure 2.7.1.2 - 1.

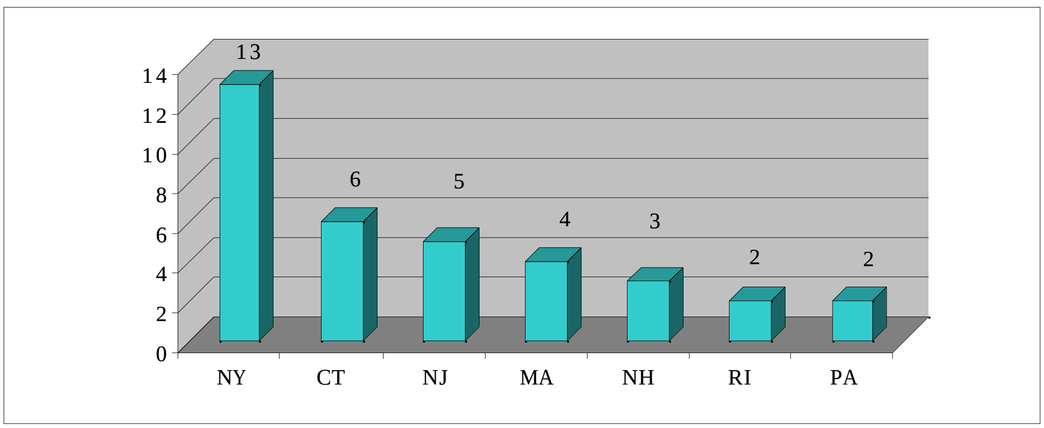

Figure 2.7.1.2 - 1 Origins of Helicopter Operations

The pilots were asked to which airports/heliports in the New York/New Jersey Metropolitan or Philadelphia areas they fly. According to the sample, LGA is the airport they use most, followed by TEB, JFK, the Manhattan Heliports, EWR, White Plains (HPN), then PHL, as shown in Figure 2.7.1.2 - 2.

2.7.1.3 Altitudes Flown

The pilots were asked at what altitudes they most commonly operate. As shown in Figure 2.7.1.3 - 1, the altitudes most commonly flown are between 3,000 and 5,000 feet AGL, although some operate as high as 6,000 feet AGL. These altitudes are normally considered high for rotary-wing aircraft that routinely operate below 2,000 feet AGL in other areas that are less congested than the Northeast Helicopter Corridor, where they are not as frequently mixed in with commercial air carriers, and where they do to not often operate IFR.

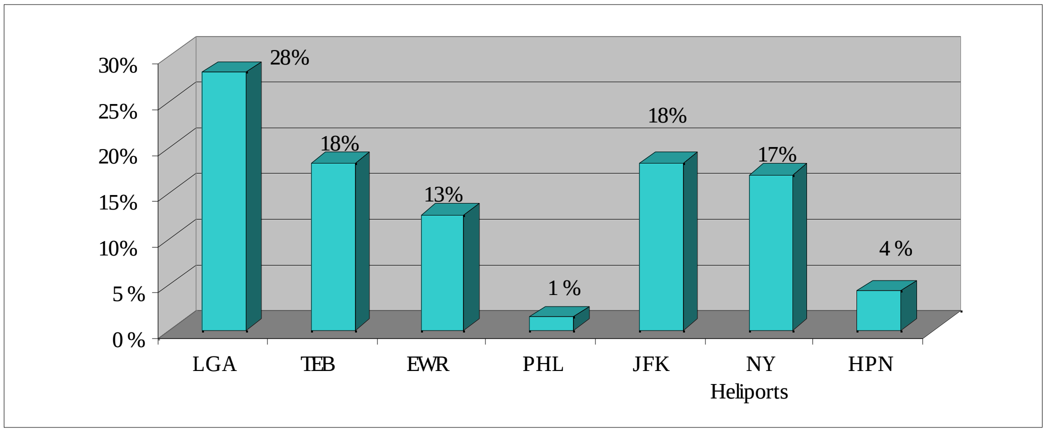

Figure 2.7.1.2 - 2 Destinations of Interviewed Helicopter Pilots

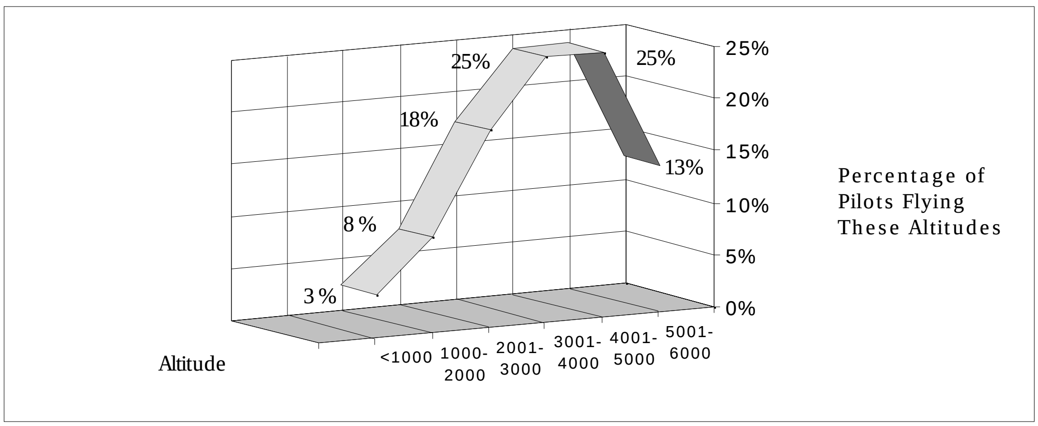

Figure 2.7.1.3 - 1 Altitudes Flown

The pilots were also asked what factors were considered when deciding which altitude to fly. There were three reasons given as to why altitudes were selected: icing, noise abatement and efficiency. The two most commonly stated reasons were icing and noise abatement at 59 and 36 percent respectively. Icing is the greatest concern. When flying under IFR, rotorcraft must fly at altitudes and along routes originally designated for fixed-wing aircraft.

It is at these altitudes that icing is more likely to occur. Therefore, it is essential that pilots avoid icing conditions normally experienced at higher altitudes, particularly during the winter. At the same time, they must be aware of the noise impact of flying at lower altitudes that may be costly due to the potential of negative community reaction. One

respondent stated "efficiency" as a reason for selecting a lower altitude because it takes longer to reach and descend from higher altitudes and also requires more fuel. Figure 2.7.1.3 - 2 shows the percentage of responses to each answer.

2.7.1.4 IFR Benefits and Constraints

The models of aircraft flown by those interviewed are all instrument certified. All but one of the pilots flies IFR part of the time. The missions normally flown by these large aircraft are

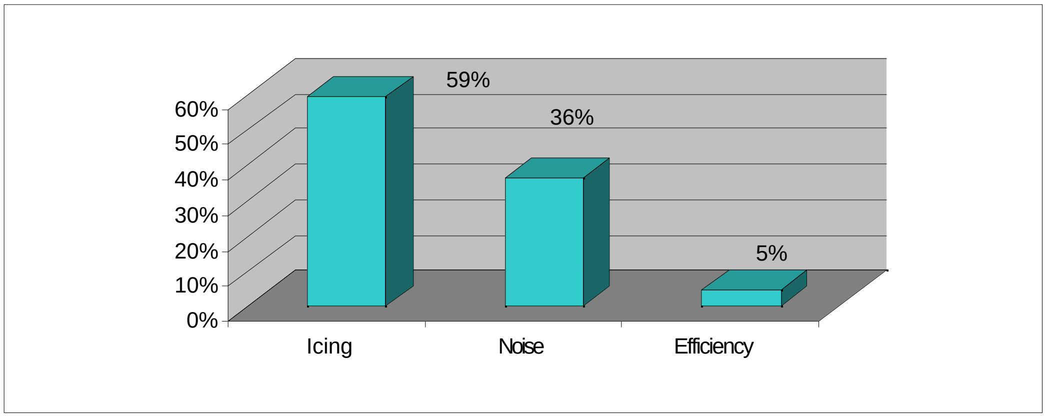

Figure 2.7.1.3 - 2 Why Altitudes are Selected

those that are expected to be a reliable form of transportation for passengers and/or cargo. Many of the operators fly corporate-executive missions and are responsible for flying high-paid executives from large corporations who expect fast, reliable transportation service.

Another common mission for rotorcraft in the northeast is express package delivery. Overnight express package delivery services have staked their reputations on meeting deadlines. A mission with a growing number of IFR operations is EMS. It is relied upon to transport severely injured or ill passengers to the appropriate facility. EMS operators often use the area airports when transferring patients from one facility to another.

Figure 2.7.1.4 - 1 presents the percentage of time that the pilots fly IFR. As the percentage of IFR time increases, the percent of pilots decreases. The highest percentage of pilots, 35 percent, operate IFR less than 5 percent of the time, while only 3 percent fly operate 21 to 25 percent of the time. No pilot interviewed flew IFR more than 25 percent of the time.

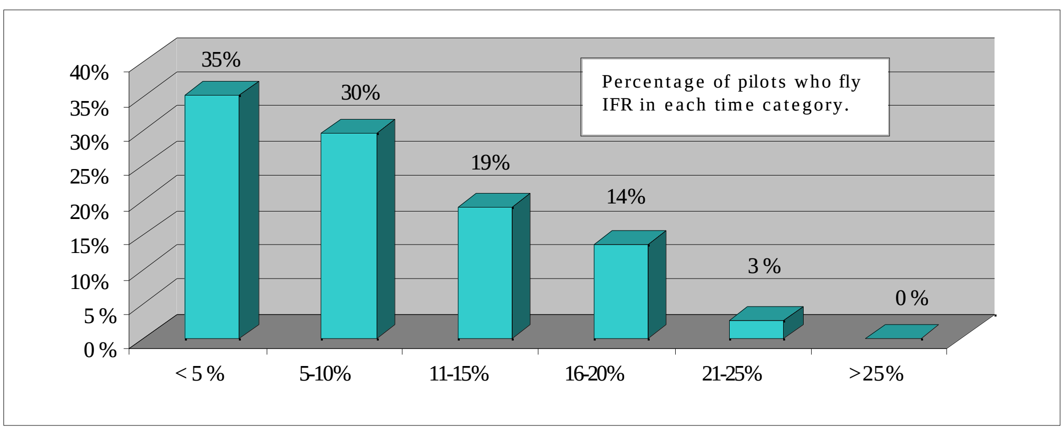

Figure 2.7.1.4 - 1 Percentage of Time Northeast Helicopter Pilots Fly IFR.

The northeastern helicopter operators choose to operate under IFR for several reasons. The predominant reason is bad weather at 81 percent. The percentage for next largest response drops to 10 percent and are those who fly IFR because of safety. The final two responses at 5 percent each were, “accurate direction when flying into an unknown area”, and “availability of an IFR facility at the destination.” This last reason implies that pilots would choose to operate IFR more often if there was an IFR capable facility at more of the destination airports or heliports, but many locations to which they fly are not instrument certified. Figure 2.7.1.4 - 2 presents the reasons given for flying IFR.

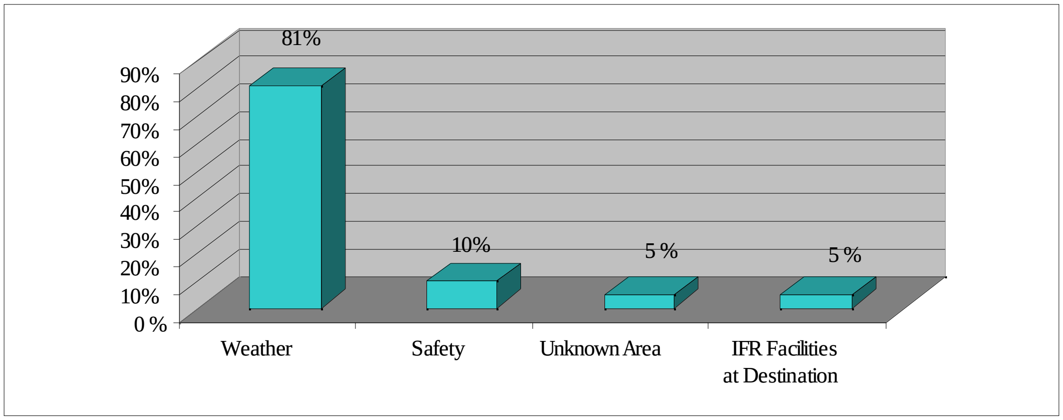

Figure 2.7.1.4 - 2 Reasons to Fly IFR.

Although pilots do operate under IFR, they indicated that there are constraints to IFR flight. The interviewees were asked two questions regarding these constraints. The first related to problems within the system that constrains IFR flight. The second concerned what factors pilots consider before making the decision whether or not to fly IFR. The answers to both questions were similar.

The interviewed pilots identified four issues that constrain IFR flight. The operators stated that IFR normally leads to additional time due to circuitous routing, lack of alternates, and fuel restrictions, and that they are more likely to encounter icing at the altitudes they are required to fly in the current route structure.

The helicopter loses the timesaving, direct flight advantage when following prescribed IFR routes, which adds more time to the mission. It was also noted that it takes more time to reach and then descend from the higher altitudes required by IFR routes. Time constraints, at 57 percent, were the most frequently stated reason for not flying IFR.

Another concern pilots have operating IFR is the lack of alternate airports or heliports along the designated IFR routes. Pilots are required to carry enough fuel to land at an alternate in case their original destination goes below minimums or is closed due to unforeseen circumstances such as heavy snow, severe icing, or ground incidents/accidents. This problem is exacerbated because there are not many IFR capable alternates available along the designated routes within range of their reserve fuel supply. This serves to limit their payload and/or range. At 34 percent, “fuel requirements” was the next most common constraint to flying IFR and “not enough alternate airports” was the response by 6 percent of the pilots.

Icing was considered a constraint by 3 percent of those interviewed. Icing is a major factor in limiting the reliability of helicopter transportation. Icing is more likely to occur at the altitudes rotorcraft are required to fly along the currently published IFR routes, particularly in winter. This problem is compounded by the fact that they are restricted from operating when there is only a forecast of icing conditions. Furthermore, if there is any doubt to the possibility of icing, the National Weather Service (NWS) will still forecast icing. The operational constraints supplied by the interviewees are shown in Figure 2.7.1.4 - 3.

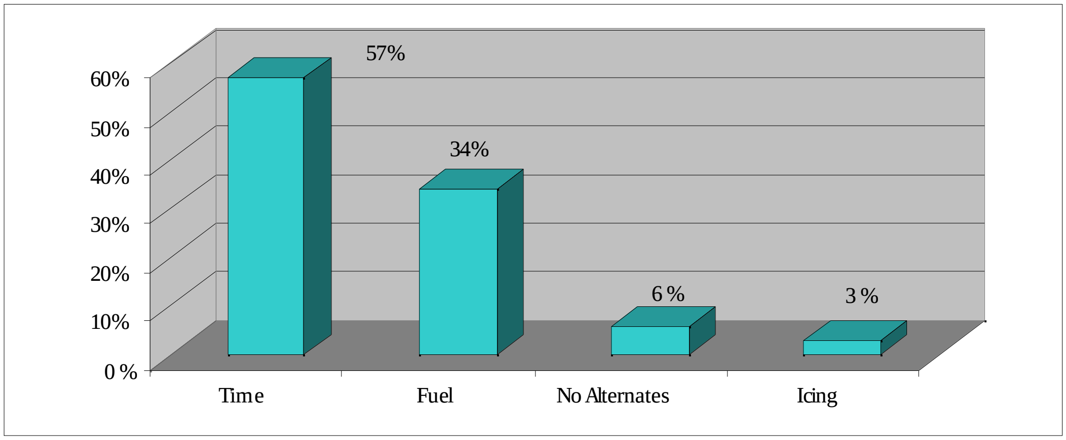

Figure 2.7.1.4 - 3 System Constraints to Flying IFR

The factors the pilots consider before making the decision whether or not to fly IFR are similar to system constraints. Time and fuel considerations again showed up in these responses. Time was by far the number one factor with a response of 60 percent. The next response received only 15 percent. That 60 percent of the pilots showed concern for time again reflects the understanding that helicopters are valued as a fast, direct, transportation mode. Pilots believe that flying the current IFR routes designed for fixed-wing aircraft reduces the efficient use of the rotorcraft fleet.

The second most commonly stated reason for deciding to not operate IFR was that "VFR is easier", at 15 percent. According to the pilot comments, IFR takes more planning and operational preparation and, unless it is truly necessary, they would prefer to fly VFR.

Circuitous routing was the third most frequent response to not flying IFR at 13 percent. This relates to the limited number of direct IFR routes for rotorcraft. IFR routes often do not take aircraft where they need to go. Fuel was the fourth response due to the same reasons discussed for operational constraints. The final reason for not flying IFR was that there is "no need". The results show pilots find it easier, faster, and more time and fuel-efficient to fly VFR. Figure 2.7.1.4 - 4 shows the reasons pilots decide not to fly IFR.

2.7.1.5 Letters of Agreement (LOA)

The pilots were asked if they had a LOAs with the any of the airports to which they fly. The response shows that 88 percent do, as shown in Figure 2.7.1.5 - 1. Figure 2.7.1.5 - 2 presents the reasons that these LOAs are written, the primary response at 71 percent, was to define SVFR procedures for rotorcraft operation at the airports. The two other responses given were "easier handling" and "time savings".

Figure 2.7.1.5 - 3 shows the airports/heliports with which operators have LOAs. In the figure, "local" indicates the smaller non-study airports where the rotorcraft operate. Ignoring the local airports because they are not differentiated, three of the four study airports were ranked as those with the highest number of LOAs. LGA and TEB both have an 18 percent response, with EWR second at 16 percent. The next three were non-study

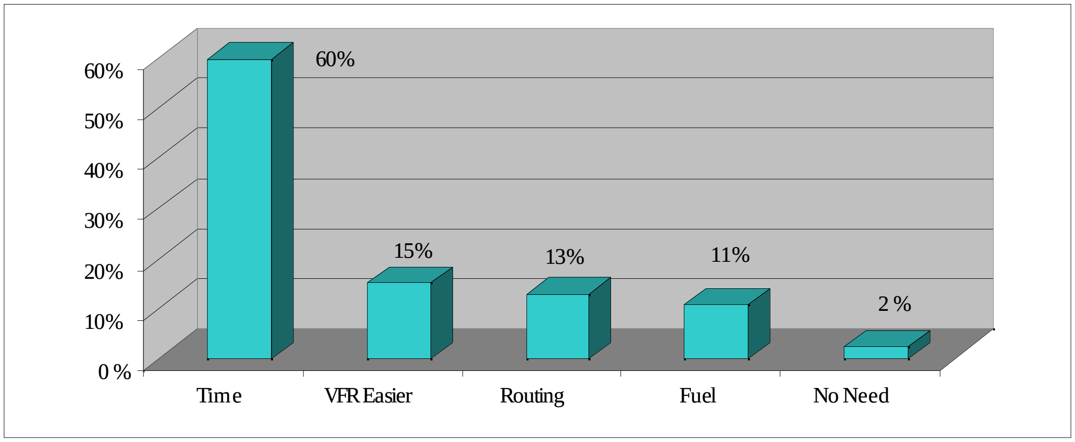

Figure 2.7.1.4 - 4 Why Pilots Decide Not to Fly IFR

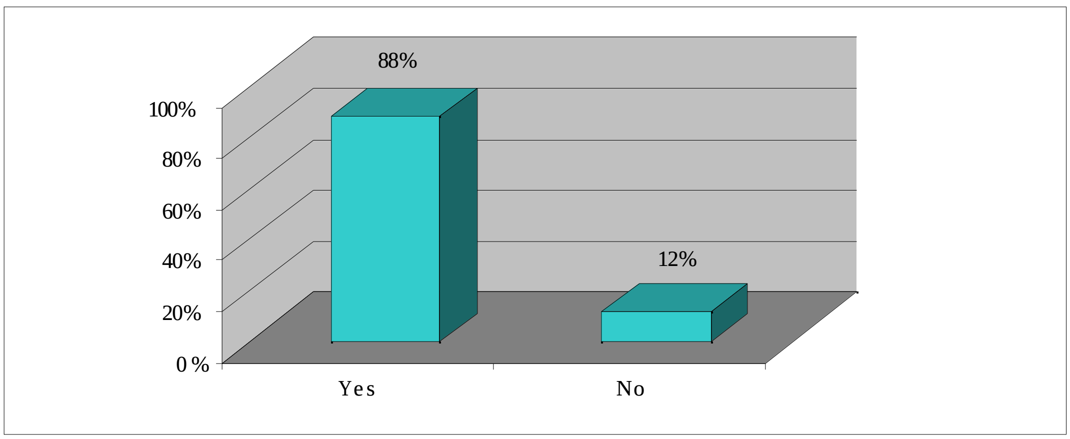

Figure 2.7.1.5 - 1 Letters of Agreement

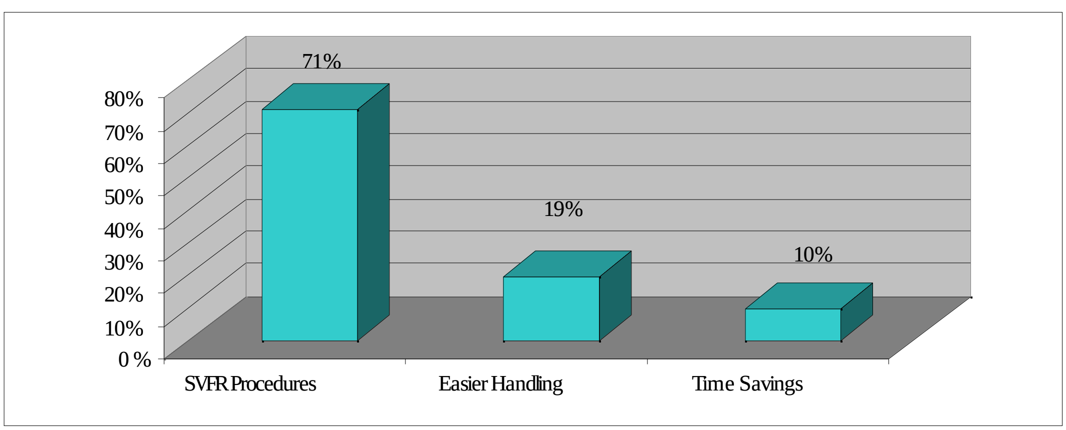

Figure 2.7.1.5 - 2 Reasons for Letters of Agreement (LOAs)

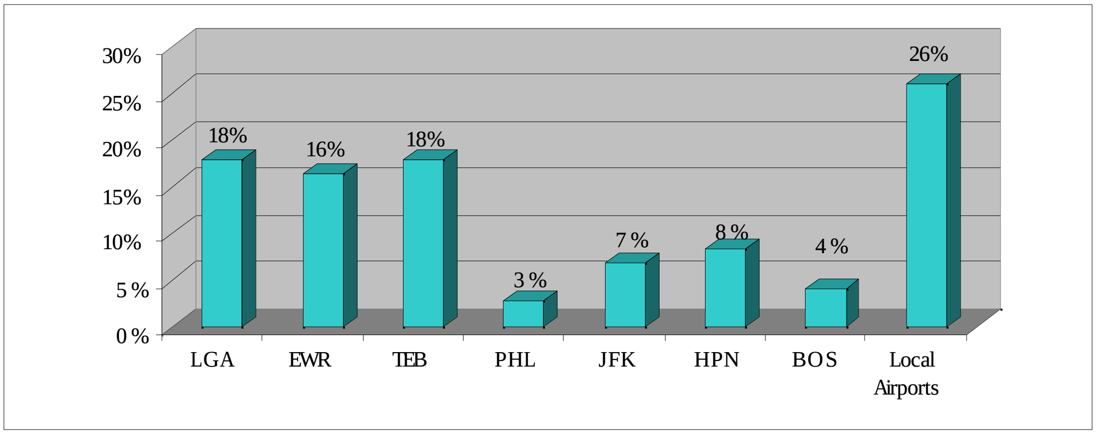

Figure 2.7.1.5 - 3 Area Airports with Whom Pilots Have LOAs

airports, with 8 percent for White Plains (HPN), where many of the study rotorcraft are based, JFK International Airport at 7 percent, and Boston Logan (BOS) at 4 percent. The fourth study airport, PHL, had the fewest number of LOAs with operators/pilots, reflecting the low helicopter traffic level that airport experiences.

2.7.2 Terminal Procedures

2.7.2.1 Approach

The most efficient instrument approach used by the helicopter operators at all study airports is the ILS. Each airport has a published "Copter ILS" that provides lower minimums than the published fixed-wing ILS. These approaches align the aircraft to the runway. Once the landing environment is in sight, helicopters can transition to land at a heliport, if available, or proceed to another destination via a SVFR clearance. The study airports that have heliports/helipads are, LGA, EWR, and PHL. TEB does not. At TEB, pilots land on the taxiway.

Of the pilots interviewed, 93 percent said they were mixed in with fixed-wing air traffic on approach to one or more of the four study airports. Of those who were mixed in, all said that they had experienced a delay or problem, as shown in Figure 2.7.2.1 - 1. The 7 percent that were not mixed in with fixed-wing aircraft were those who said they used the "off-duty" runway or were EMS operators who had a patient on-board and were therefore given priority handling.

However, 61 percent said they had no conflicts with fixed-wing aircraft on approach. Those who had no conflicts said that they were "fast enough" to keep up in sequence. Of the 39 percent who said they did experience some conflict with fixed-wing on approach, most said it was only when the weather was at or close to minimums when they are required to execute an approach to the runway. The results of this question can be seen in Figure 2.7.2.1 - 2.

2.7.2.2 Departure

On departure, when the weather is below visual minimums, pilots will fly a published departure procedure from the airport. However, all require a clearance whether requesting SVFR or IFR or departing from a heliport or another location within the controlled airspace.

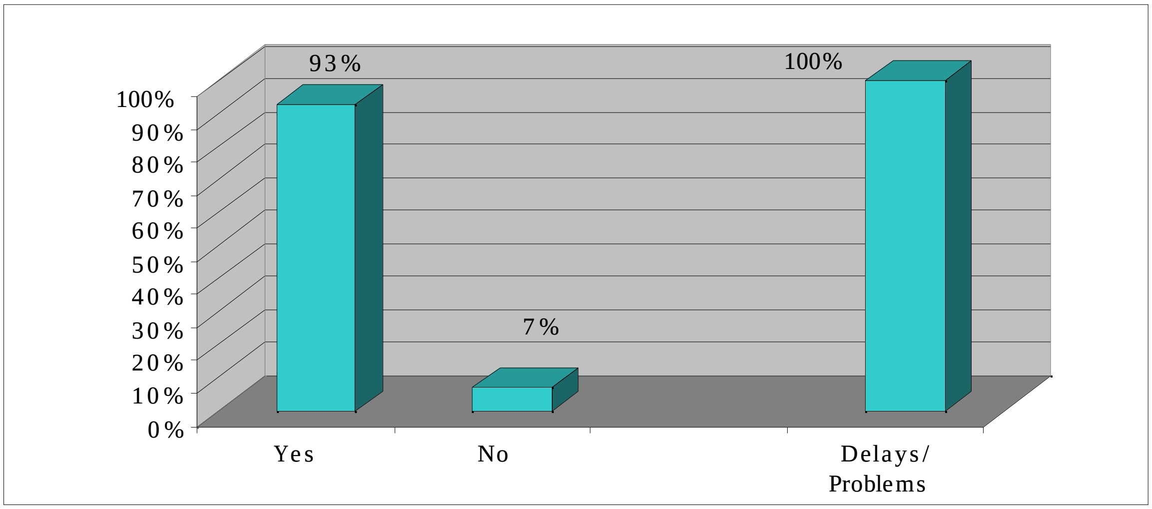

Figure 2.7.2.1 - 1 Mixed In with Fixed-Wing Aircraft on Approach

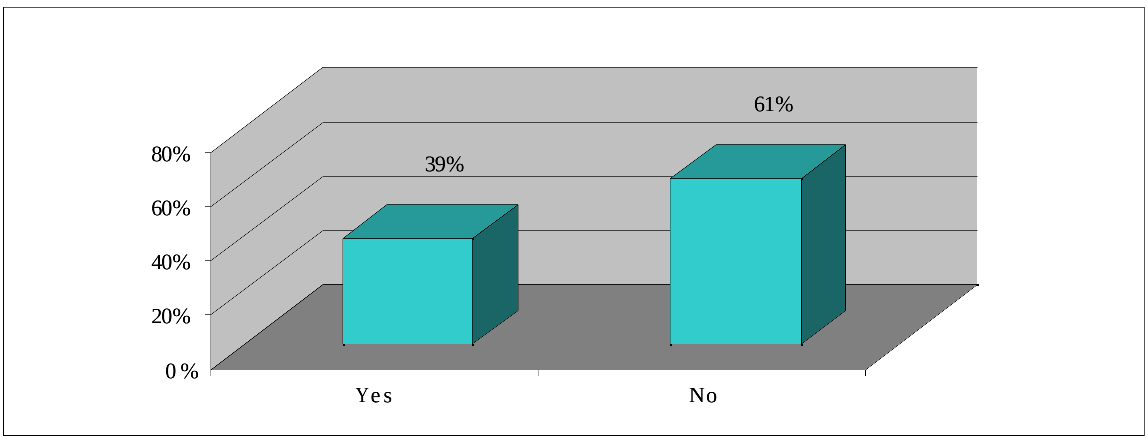

Figure 2.7.2.1 - 2 Conflicts with Fixed-Wing on Approach

In answer to the question whether they are mixed in with fixed-wing on departure, the responses were “yes”, “no”, or “in sequence”, or “in sequence but leave from heliport”. This means that the rotary-wing aircraft are sequenced in the same departure queue with fixed-wing aircraft while waiting for a departure clearance. Some pilots interpreted this as being “mixed in with fixed-wing”, but others, since they do not fly the published SID, but receive a departure clearance that allows them to fly a requested heading, interpreted this as not being mixed in. This is reflected in Figure 2.7.2.2 - 1 that shows that although 61 percent of pilots answered that they are mixed in with fixed-wing aircraft and 39 percent said they were not, 55 percent of all respondents said they were “sequenced”.

Only 15 percent of the respondents stated that they have conflicts with fixed-wing aircraft on departure, saying that there was no problem in the regular sequencing. In fact, 85 percent said that they have no conflicts. Of the ones that do have conflicts, the main

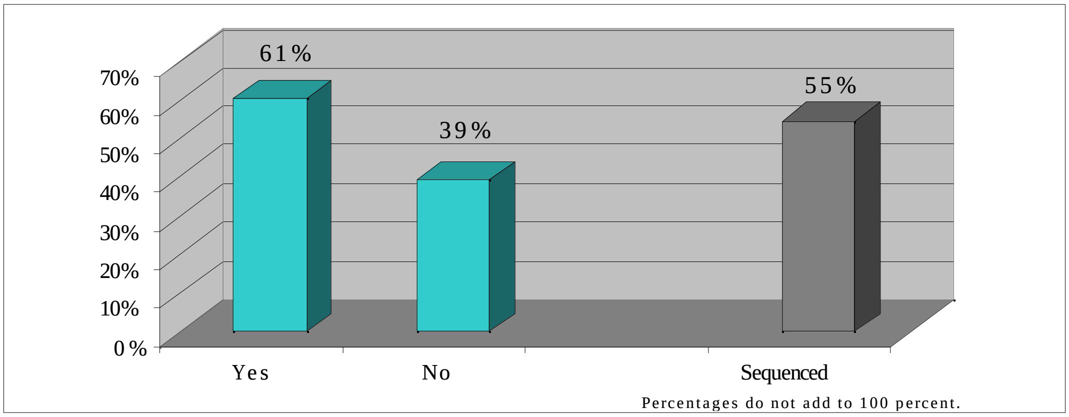

Figure 2.7.2.2 - 1 Mixed In with Fixed-Wing Aircraft on Departure

issue was that they have to wait for fixed-wing aircraft or are put at "the end of the line". Others said they had conflicts only if the weather was very bad or if they were departing in the same direction as the fixed-wing. The results are shown in Figure 2.7.2.2 - 2.

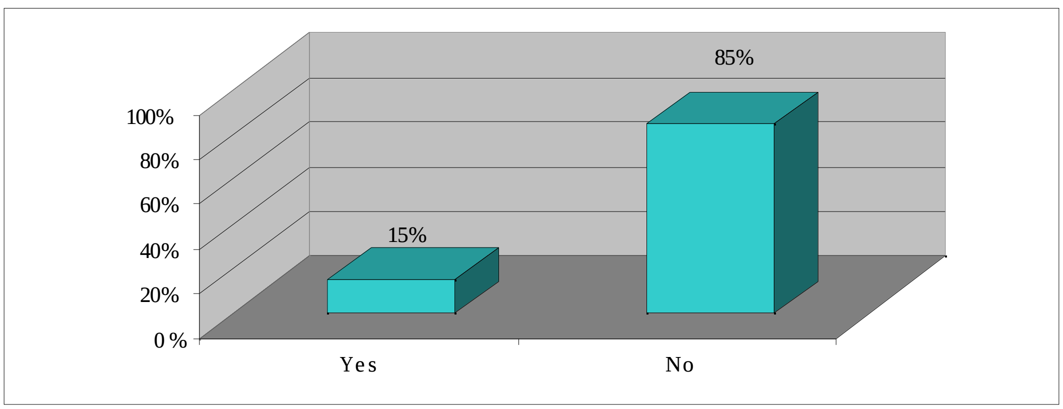

Figure 2.7.2.2 - 2 Conflicts with Fixed-Wing on Departure

3.0 POTENTIAL SITES FOR SNI APPLICATION

This section discusses the operational aspects associated with the application of an SNI concept at each of the study airports using data collected and described in section 2.0. As a result of this investigation it is clearly evident that there is no one solution to the intertwined network of terminal and en route policies and procedures. It is also evident that numerous rotorcraft operators that transit the study airspace on a daily basis and the national rotorcraft organizations, do not necessarily have the same perspective on operational requirements.

The regional and local ATC management have, for the most part, taken a proactive approach to working with the vertical flight community. For example, the New York TRACON (N90), which is larger than the TRACON co-located at the PHL ATCT, has continually maintained an active involvement in addressing the issues associated with VFR and IFR rotorcraft traffic. They maintain a working relationship with representatives of both local operators and regional organizations in an effort to “make it work”. The operators also provide the same level of perseverance to find the best alternatives to work within the system.

Previous research efforts have identified a number of the same issues that relate to developing procedures and standards to allow for the safe and efficient simultaneous IFR operations of rotary- and fixed-wing aircraft in dense terminal and en route environments. A variety of suggestions and recommendation have been introduced over the course of these studies. Each inquiry offers a revised approach with high expectations, with only minimal results. The majority of successes have come about where local operators deal directly with local ATC. However, even with over fifty years of active flight operations in the NAS, rotorcraft still only represent a small percentage of overall air traffic activity.

Over the years, the FAA has conducted many studies in an attempt to rectify the imbalance in air traffic situations without imposing penalties on one class or type of user over another. As an example, results from the National Airspace Review (NAR) conducted in the early 1980’s reveal that rotorcraft had not been properly integrated into the air transportation system. The review stated that rotorcraft have been forced to:

- Operate in airspace that was designed for fixed-wing aircraft,
- conform to standards that were established for fixed-wing aircraft, and
- adapt to procedures that had been designed for fixed-wing speeds and maneuverability.

The ultimate resolution for the northeastern United States was the creation of the Northeast Helicopter Corridor. Although beleaguered with operational problems, the corridor was a first effort that needs to be revised for the next century. Significant improvements in rotorcraft performance, airborne navigation, and ATC support systems have taken place over the past two decades. Even though rotorcraft are a small percentage of the total aircraft traffic in the study area, its use as a mode of transportation continues to expand. Next generation procedures that support vertical flight should be established.

3.1 Traffic Pattern Generation Factors

The following section addresses issues associated with repetitive situations and SVFR applications. It looks at the factors that generate arrival and departure patterns at a particular airport and examines issues associated with separation of aircraft and the availability of SIAPs.

3.1.1 Repetitive Situations

Most of the study facilities experience repetitive situations and have worked out satisfactory methods of handling them. To those involved, these methods are routine and not dynamic enough to document as major improvements in the IFR flow. In other words, no one sees these as special procedures that would significantly increase overall capacity. There is improvement in the IFR flow, but it is limited to due the small numbers of rotorcraft in the total volume of air traffic. These are simple routine handling applications that have become standard procedures to expedite the flow of IFR rotorcraft operations. For example, although there are few IFR rotorcraft in the PHL Class B airspace, a procedure has been developed that benefits ATC and operators alike. Normally the arriving and departing traffic flow is to runway 27R/L, but when an IFR or VFR rotorcraft is inbound to the airport, the TRACON vectors it on a course or approach to runway 17. This is beneficial to the rotorcraft operators because the approach end of runway 17 is close to the GA terminal that most rotorcraft operators use to discharge and/or pickup passengers, or refuel, as required. For the most part, this action takes rotorcraft traffic out of the primary flow of IFR traffic to the airport and provides a simultaneous, yet separate, approach and departure corridor. In this way, ATC is accommodating the helicopter operators as well as having developed the most efficient operational procedure for all traffic.

The approach to runway 17 may not be considered an important issue by the air traffic controllers, but it provides insight into a prototype procedure that offers value to rotorcraft operations at PHL. The degree to which this type of procedure could impact rotorcraft IFR operations varies by airport. Each of the study airports have some type of simple procedure that allow rotorcraft to transition off a published SIAP or visual procedure to a helipad, another on-airport area, or to proceed SVFR to other area heliports or landing locations. The value here is that rotorcraft have been removed from the IFR flow at a point in advance of what was expected for the arrival flow and that the operational performance characteristics of the rotorcraft are advantageously applied.

The volume of rotorcraft traffic varies among study airports, but generally LGA has the highest level followed by TEB, EWR and PHL. Each airport has a “Copter ILS” SIAP published to support rotorcraft activity. The minimums for these procedures are lower than those for fixed-wing and therefore allow rotorcraft access to the airport at times when fixed-wings are restricted. Even with lower minimums and ability to transition to other areas, rotorcraft air traffic must still be sequenced with all the other aircraft on final to a runway. This ultimately leads to a delay in the flow due to the speed differential between rotary- and fixed-wing aircraft, because controllers tend to provide ample separation to ensure that one aircraft does not over take another. The result is that the arrival flow is elongated or stretched out to build a window for the rotorcraft.

With this in mind, one element that must be considered for any SNI development is removing the rotorcraft from the standard IFR flow in and out of the airport. Whether or not a separate en route network is developed is not the issue. The key to successful implementation is to provide an independent flow that is not linked to the standard fixed-wing paths. An important point was mentioned at all facilities—that no matter what is proposed, it must be accomplished in the existing airspace. Airspace is a finite element that cannot be expanded. It can be partitioned, divided, or sectored to provide a more efficient use, but an additional layer cannot be added for rotorcraft.

3.1.2 Special Visual Flight Rules (SVFR)

Review of the operator and ATC interviews clearly indicates that SVFR procedures provide a key ingredient to success of helicopter operations during marginal VMC or in some cases IMC. Considering the delays normally associated with IFR for rotorcraft, most operators elect to conduct operations via SVFR procedures. For the most part, operations under SVFR provide virtually the same benefit as VFR, but eliminate most of the limitations imposed by IFR.

The two busiest facilities, LGA and EWR, have LOAs with specific operators that authorize SVFR helicopter operations within their designated airspace. Appendix E shows an example LOA for LGA. The use of SVFR procedures is a significant operational link when the weather is considered marginal. Most rotorcraft do not land at the airport for which they are on approach. The common practice among facilities is to put the rotorcraft on a published SIAP, usually the “Copter ILS”, and at a point where SVFR minimums can be maintained, permit the rotorcraft to proceed via SVFR to its intended destination. This procedure is executed so often that it is considered routine for both the controller and participating operators.

The successes of SVFR procedures in IMC offer potential for developing an SNI concept at each of the study airports. There are obviously some elementary differences between SVFR and an SNI concept, but SVFR could serve as a template for developing a prototype SNI matrix in terminal airspace. By examining specific course and altitude selections associated with SVFR operations, a three dimensional model could provide a first-level model of potential SNI procedures in terminal airspace. In addition, through the application of new technologies, such as GPS and ADS-B this model could further be enhanced to render an IFR procedure that is separate and distinct from those that support fixed-wing aircraft.

3.2 Special Priority Handling Penalties and Benefits

3.2.1 In-Flight

Rotorcraft sometimes have a difficult time operating in the IFR environment. Aside from the fact that the route structure is based on fixed-wing performance, the general characteristics of the instrument flight rules do not take into account the operational advantages of rotorcraft. For instance, the lower speed of rotorcraft is often considered a detriment. Yet, in an environment where precision GPS approaches will require a decelerating procedure to minimal operating flight airspeed, the issue of slow speeds becomes an asset.

Even though specific VFR and SVFR procedures have been perfected at the study airports to allow a variety of operations to occur within controlled airspace, rotorcraft still face penalties while operating either VFR or IFR due to lower speed. Consequently, ATC routinely delays or restricts rotorcraft operations in an effort to expedite fixed-wing, or fast moving aircraft operations. The assumption is that the slower moving rotorcraft requires considerably more separation. Furthermore, due to the unique flight characteristics of rotorcraft, they can easily be placed on a diverging course, thereby eliminating any perceived separation conflict, despite its slower speed. The unique operating characteristics of rotorcraft can be positively applied rather than considered restrictive and limiting.

SVFR procedures enhance ATC and rotorcraft operability during IMC. It can be considered a special handling benefit by allowing rotorcraft to operate SVFR in less than VFR conditions. Although the aircraft must obtain a clearance and meet certain flight conditions, SVFR empowers rotorcraft with a special advantage to continue to operate visually. This benefit needs to be continued and examined to determine if the lessons learned through SVFR can assist in developing the first level SNI routes and altitudes.

The operational capability of rotorcraft has substantially improved over the past decade and their missions are expanding to a point that in the northeastern United States an all-weather capability is becoming a necessity to meet operational requirements. Rotorcraft need full and equal service when the airports or landing sites are less than VFR. As the requirement for increased capacity and improved throughput for air carriers and other fixed-wing aircraft remains a high priority, issues associated with rotorcraft appear lower on the list. This is apparent in the daily airport operations where slower aircraft are frequently delayed in order to expedite the movement of faster traffic. This procedure is understandable when two or three air carrier arrivals or departures can be accomplished within the same time or space that a single rotorcraft requires. However, it is a marked penalty for rotorcraft that requires attention by all involved, the FAA, industry and particularly the operators, who have been the most active, and without whom very little would change.

3.2.2 Ground

At most study airports rotorcraft operations are allowed to break off from the routine ground flow and proceed directly to the heliport/helipad or designated parking area via ground or hover taxi. Variation on when transition occurs depends on airport weather conditions, designated taxi routes, and amount of ground traffic.

Depending on the location of the on-airport heliport/helipad, in most situations it is extremely rare to have rotary- and fixed-wing ground traffic mixed together in the same area for departure. However, it is possible that a rotorcraft may request departure from locations on the airport that may be in proximity to fixed-wing ground traffic.

3.2.3 Impact on FAR Part 121 Air Carriers and Regionals

There appears to be no conflict between CFR Part 121 air carrier and regional operations and rotorcraft based on discussions with controllers at all facilities. Even when rotorcraft operations are IFR, the majority do not land at the airport providing them approach services. At some point during the approach there is a transition via SVFR to another landing site, thereby removing it from the IFR flow. Although, according to ATC, rotorcraft IFR landings at an airport are relatively infrequent, any slow IFR traffic will have some effect on the flow of arrivals and departures despite the type of aircraft.

It should be noted that this study did not include any interviews with Part 121 operators. It would be wise to include air carrier pilots and management concerns when the SNI investigation is taken to next level.

3.3 Alternate IFR Approach/Departure Paths

Depending on the operational characteristics at each location, there may be a need to develop alternate approach and departures paths for rotorcraft. The level to which this is accomplished may, or may not, be to the current level of the industry-defined SNI concept. However, some procedure that separates rotary- and fixed-wing IFR traffic flows would be beneficial to the IFR operational efficiency of both.

At airports that experience low IFR rotorcraft traffic counts, similar to PHL, it is evident that dynamic SNI procedures are not now necessary. Some procedural enhancements may be needed to improve coordination between facilities and throughput of rotorcraft transitioning their airspace, but SNI procedures would not be required. At locations that match or exceed the volume of IFR rotorcraft traffic at LGA, innovative SNI procedures would be very beneficial as a non-interfering method of handling both SVFR and IFR traffic.

3.3.1 Approach Paths

The publication of non-precision GPS criteria for rotorcraft offers a starting point for developing stand-alone SIAPs for rotorcraft that removes the airport runway from the equation and permits the use of realistic PinS and heliport instrument procedures. Although, as with any instrument procedure, GPS procedures are sensitive to location of obstacles, protected airspace, and other air traffic, they can be placed in areas that are considerably more confined than those that now support fixed-wing aircraft or “Copter” type approaches or departures. For example, at LGA where a majority of rotorcraft traffic transition to other destinations, a non-precision GPS PinS procedure could be developed to a point west of the airport that coincides with current SVFR operations. This would provide an IFR flow separate from fixed-wing aircraft and away from the centralized traffic flow in and out of the airport. Similar procedures could be considered at other airports with a high volume of transitional IFR rotorcraft air traffic.

At locations where there is considerable IFR rotorcraft traffic that land at the airport, GPS criteria could serve as the basis for providing a non-interfering instrument procedure. It must be understood that the versatility of rotorcraft over fixed-wing aircraft is the key element in developing these procedures. A rotorcraft does not have to align with the runway to make a successful landing at an airport. As the example in the previous paragraph shows, a PinS procedure could be developed in the vicinity of the airport. This would remove the rotary-wing traffic from the routine fixed-wing approach path. It is not an easy task, because each of these procedures cannot interfere with the protected airspace of other instrument approach or departure procedures and more important, the missed approach areas can not overlap.

3.3.2 Departure Paths

The versatility of the GPS signal is such that it is not sensitive to whether an aircraft is either proceeding to or from a landing site. Except when there is inbound air traffic, the path into a facility can be used as the path from that same facility. Rotorcraft do not need a runway. Using GPS, state-of-the-art rotorcraft departures could be designed to proceed away from other inbound or outbound air traffic. A variety of GPS based SIDs could be published, allowing rotorcraft to proceed out of the immediate airport environment, connect to a preferred IFR or TEC route then continue on routinely to their destination.

3.3.3 Alternate Route Structure

Altitude is another major point of confusion that continues to go unnoticed in defining an alternate route structure. It has been assumed by many that the rotorcraft community needs a quasi victor airway structure in high volume traffic locations such as the Northeast Helicopter Corridor. Although the Northeast Helicopter Corridor was offset from the primary airway flow, it was patterned after the fixed-wing environment. Assigned altitudes in the corridor range from as low as 1,700 feet to a maximum of 5,000 feet. At these altitudes, there is uneven radar coverage at best. As part of this investigation, the issue of providing a non-interfering low-altitude structure was to be considered based on the same altitude range. However, as indicated by the helicopter pilot interviews, rotorcraft would like to be able to fly IFR at altitudes ranging from 500 feet to 1,000 feet AGL. When considering IFR flight in controlled airspace, especially congested Class B airspace that belongs to N90A in the Northeast Helicopter Corridor, the lack of radar coverage presents significant limitations, whether en route to or from LGA or EWR. It is even more difficult to consider providing an actual low-altitude IFR route structure for rotorcraft when coverage cannot be secured at all requested altitudes.

With the advent of "free flight" and continued research into potential applications of ADS-B, it is reasonable to assume that some level of positive control will be provided in areas that are now obscured from radar, especially with successful results of test projects like Operation Heli-STAR (Section 2.1.8.2). Once positive separation and sequencing throughout the altitude spectrum of controlled airspace can be provided without restrictions, then a truly separate and non-interfering route structure can be undertaken.

3.4 SNI Needs Assessment

The terminal and en route operating environment included in this investigation is marginally acceptable from a rotorcraft perspective based on comments provided by ATC, area procedures specialists, and local rotorcraft operators. There is always room for improvement, but the cooperative effort of both ATC and pilots make the system work. ATC does its best to appropriately merge both rotary- and fixed-wing air and ground traffic to provide an expeditious flow.

Understanding a key point in handling air traffic is necessary. Control decisions are regularly made, and although the basic rule is "first come, first serve", this is not always the case. In order to maintain an expeditious flow, occasionally slower aircraft may encounter a slight delay to allow faster aircraft to continue. This by no means indicates that the system is broken, but that it may need to be augmented. This investigation has revealed that improved guidance and more appropriate procedures that focus precisely on issues associated with rotorcraft and ATC requirements are needed. If both ATC and local operators were provided with procedures that improve traffic flow, eliminate rotary- and fixed-wing competition, and allow rotorcraft to fly with more flexibility in the system, most of the current dilemma might not exist.

For years, positive statements from volumes of investigative research have touted the unique operating characteristics of rotorcraft. Although, earlier procedures provided some advantages, not until publication of helicopter GPS non-precision approach criteria in 1997, were these characteristics realistically reflected in an instrument approach procedure. The improved navigational accuracy that is provided by satellite technology has permitted overall reduction in trapezoidal dimensions in published criteria. With the same level of safety, non-precision GPS approaches for rotorcraft can be developed in places that were once considered unacceptable for instrument procedures. Ongoing programs are continuing this work and hoping to expand the envelope to include a precision capability in the near future.

The vertical flight industry has plainly stated its agenda in a white paper presented to the FAA Administrator in July of 1998 titled, "Developing a Safe and Efficient Vertical Flight Infrastructure" (Appendix F). An essential goal of this paper is the development of an air and ground infrastructure for rotorcraft based on the concept of simultaneous non-interfering procedures to include heliport-to-heliport all-weather operations. The results of this investigation firmly support development of some type of SNI procedure in high volume areas. However, unless that support is unanimous, and all participants including, operators, providers, and users are involved, the effort will not result in any consequential changes.

Recent efforts developing pseudo SNI procedures in the private sector have proven to be very successful. The number of private rotorcraft GPS approaches has rapidly increased as one company, Satellite Technologies Implementations (STI), has been actively developing private-use SIAPs for a variety of customers. Under an agreement with the FAA, STI develops the entire procedure package and submits it directly to the FAA quality control program. This has significantly compressed the turn around time from procedure start to publication. The significant issue here is that in the process of developing independent GPS SIAPs, STI has been able to network together a variety of private GPS SIAPs in the same area to form a low-altitude GPS network. Although ATC handles all IFR traffic in the same manner, these heliports are in such close proximity to each other it is as if a dedicated network is being provided. The majority of these procedures support EMS helicopter operations. At some locations as many as 22 approaches have been networked together (Appendix G). The need for EMS operators to perform patient transfer from an on-scene site or to proceed from hospital to hospital is routine. In the past, while lives hung in the balance, EMS transport was accomplished via ground vehicles that were dependent on local road conditions. With the publication of the non-precision GPS criteria for rotorcraft, STI has been able to assist EMS operators into a full-scale operation that now includes IFR approaches to hospital heliports. The potential application in the civil world, especially considering congested airspace similar to that of N90, is virtually endless. If anything, it bears an in-depth assessment of how ATC in these other locations handle this influx of new instrument procedures.

4.0 CONCLUSIONS

The conclusions are the result of the investigative effort performed in support of the NASA SNI task assignment. Due to the nature of the investigation, they have been segregated into the two major operational areas, ATC and rotorcraft. This is designed to delineate fundamental issues by area and offer a detailed perspective on issues that directly relate to exploring an SNI concept.

4.1 Air Traffic Control Operations

4.1.1 Air Traffic Control Awareness

Although, traffic services are normally provided without incident, there appears to be a lack of familiarity with the operational capabilities of rotorcraft at some ATC facilities. Controllers understand that rotorcraft are different from fixed-wing, but they have an instilled misperception that this difference should prohibit rotorcraft from conducting operations in the same airspace as fixed-wing. The element that most controllers comprehend and use is the ability of rotorcraft to hover, because it can instantly provide the anticipated or required separation between aircraft.

4.1.2 Rotorcraft Performance Characteristics

The adaptability of rotorcraft should be exploited to enhance air traffic operations rather than restrict them. Rotorcraft are notably more versatile, and depending on type and model, can cruise at airspeeds from 90 to 160 knots, which is compatible with most fixed-wing approach speeds. Rotorcraft can maneuver in significantly less airspace than fixed-wing aircraft and do not require a runway to land. Recently published non-precision GPS criteria take advantage of satellite technology as well as the operating characteristics of rotorcraft. These procedures should be the rule and not the exception and could be the basis of an SNI concept.

4.1.3 Radar Coverage Restrictions/Limitations

Radar coverage is a significant concern in the Northeast Helicopter Corridor. The altitudes at which rotorcraft request to fly are low enough to either be screened from radar identification by ground obstructions or be below the limits of the radar service area. An augmented system is necessary to provide minimal surveillance coverage in these areas. The FAA is exploring new technologies that could maintain surveillance and positive control of aircraft through a combination of primary and secondary radar and broadcast of satellite-derived position information from individual aircraft.

4.1.4 GPS Navigation

The application of GPS as the sole means of navigation throughout any SNI structure is not feasible at this time. As stated in the JHU/APL report (Section 2.1.7.1), GPS with LAAS and WAAS can satisfy the required navigational performance and function as a sole source for navigation. However, both systems are still in the developmental stage and are not projected to become operational until 2001. In addition, there are known risks to GPS signal reception that must be managed. Steps must be taken to minimize the effects of intentional interference. Finally, a definitive national GPS plan and management commitment is needed to establish system improvements for civil aviation users and provide greater information access to the civil aviation community.

4.1.5 Limited Rotorcraft SIAP Availability

There are no stand-alone rotorcraft public-use SIAPs. Each of the study airports has a published "Copter ILS" approach, but this procedure is limited in its ability to reduce delay and increase capacity. The localizer and glide slope for an ILS approach are locked into a specific runway and cannot be realigned to provide service to another location on the airport. Although, on an ILS approach, once the landing environment is in sight, the pilot can cancel IFR and proceed visually to the designated landing area, it does not remove the rotorcraft from the fixed-wing traffic flow.

A rotorcraft in the ILS flow is in direct competition with all other aircraft en route to that airport whether it actually lands at the airport or not. However, rotorcraft are not bound to a specific landing surface, such as a runway. Helipads, or on-airport heliports, that are well removed from the active flow of fixed-wing traffic can be provided with an independent non-interfering non-precision GPS procedure. This should be actively pursued to provide rotorcraft with an alternate public-use instrument approach procedure.

4.1.6 SVFR Advantage

SVFR is example of a certified procedure that allows rotorcraft to apply their unique operating characteristics in the fixed-wing structure. It is evident that SVFR significantly contributes to the success of rotorcraft operations during marginal weather conditions by granting them virtually unrestricted clearance within controlled airspace in less than VFR conditions. SVFR provides an important link between VFR and IFR procedures that is unrivaled in today's operational environment. Enhanced or augmented SVFR procedures could offer a foundation for developing a SNI network. An in-depth assessment of the merits of SVFR should be performed to ensure that both SNI and SVFR procedures are compatible.

4.1.7 Existing Airspace Requirements

The airspace that comprises both PHL and N90 is congested and densely populated with a variety of airports and heliports as well as a wide assortment of aircraft. The most limiting factor is airspace. Any new, revised, or amended procedure must be accomplished within existing airspace parameters. The airspace may be reapportioned to provide different levels of service for any number of users, but the reality is that the allocated space is finite. We cannot "grow" airspace and two aircraft cannot occupy the same space at the same time. With this in mind, it is necessary to examine those areas that are currently under utilized and explore the potential to support SNI procedures within these areas. Most of these areas are at altitudes that are not routinely used. New technologies offer the potential to provide positive surveillance in these otherwise unusable areas thereby gaining supplemental airspace.

4.1.8 Vertical Flight Committee

The FAA Administrator has directed the establishment of the Vertical Flight Committee that is to address the following issues:

- Serve as the focal point for coordinating FAA action on rotorcraft issues, both within the FAA, industry, and other agencies,
- incorporate the Gore Commission and FAA "Safer Skies Program" into FAA helicopter/tiltrotor initiatives,
- review FAA policy, plans, programs, and regulations to assure appropriate consideration is given to the needs of the community,

- facilitate the integration of rotorcraft/tiltrotor aircraft into the NAS to improve capacity and reduce delays, and
- make recommendations for the development and improvement of air and ground infrastructure.

The committee will be chaired by the FAA National Resource Specialist for Rotorcraft Operations and committee membership will include representatives of the major FAA lines of business that comprise; Aircraft Certification, Flight Standards, Airports, Air Traffic Services, Research & Development, and Environmental. In an effort not to duplicate work, so that one organization is aware of what the other have accomplished, both government and aviation industry would do well to monitor the progress of this committee.

4.2 Rotorcraft Operations

4.2.1 Unique Operating Characteristics

It is unanimous that rotorcraft have unique operating characteristics. Most operators believe that ATC understands this fact. The issue at hand is to successfully employ these characteristics to the benefit of both ATC and systems users. There is a variety of different rotorcraft in the active inventory and each has something to offer ATC. Rotorcraft continually assist ATC by complying with a variety of one-time requests. The procedures resulting from these requests and the versatility of rotorcraft need to be developed into routine operational procedures.

4.2.2 Rotorcraft Operational Advantage

The primary reason rotorcraft are used is for fast and direct transportation. Rather than driving from Bridgeport, CT to Manhattan, which, depending on the time of day, could take a number of hours, rotorcraft can be a direct link with virtually no delays. However, if the weather is less than VFR, this trip takes on a significantly different structure when considering flight within the current IFR route structure. Fast and direct transportation is necessity to maintain a positive profit margin. The increased in mission time is one of the main concerns noted by the operators interviewed (Section 2.7.1.4). If a pilot or operator has a choice with regard to VFR or IFR, many do not choose to fly IFR due to these additional time constraints.

4.2.3 Direct IFR Routes

The current fixed-wing IFR environment does not offer the direct routing that rotorcraft operators need to actively participate in IFR operations. Published procedures are not compatible. Rather than proceeding directly to a final destination, rotorcraft are routed in such a matter that additional flight time is required, fuel management becomes a critical factor, and passengers are inconvenienced. Transportation via rotorcraft is primarily intended to be short distance, approximately 250-350 miles. Any additional routing other than a direct point-to-point thwarts the primary advantages associated with rotorcraft operation. In fact, the overall rotorcraft advantage can be effectively eliminated. To actively participate in IFR flight rotorcraft must have dedicated low altitude direct routes.

4.2.4 Icing Conditions

In developing or managing any airway structure for rotorcraft, serious considering must be given to icing conditions at altitude. Although technology can now de-ice rotorblades, it is very expensive and is currently only being used by the military. The majority of rotorcraft are very susceptible to icing at specific altitudes depending on the weather conditions. This is another fact about rotorcraft of which most controllers are unaware. Aircraft familiarization is an essential part of ATC, it is extremely important to understand which aircraft can operate under what conditions. Keeping rotorcraft operations below the freezing level is a safety concern that requires the utmost attention.

4.2.5 IFR Alternate Heliports/Airports

One of the restricting factors that impedes rotorcraft from participating in IFR operations is the limited number of available alternate facilities. Due to this, the amount of fuel reserve they must carry limits their payload and/or range. The FAA has issued a notice of proposed rulemaking (NRPM), Notice Number 98-12, “Flight Plan Requirements for Helicopter Operations Under Instrument Flight Rules”. This NRPM has undergone one round of comments and the FAA is issuing a Supplemental NRPM for review in spring of 1999.

4.2.6 Industry White Paper

The national organizations that support the helicopter industry, both manufacturers and operators, published a white paper titled, “Developing a Safe and Efficient Vertical Flight Infrastructure,” and presented it to the FAA administrator in July 1998. In this paper they clearly state their goal for the vertical flight industry for the next century. The following is a direct quote of that goal:

> “The development of air and ground infrastructure for rotorcraft operations based upon the concept of simultaneous non-interfering operations and heliport to heliport all-weather operations through an FAA/industry partnership composed of an integrated product team, which includes FAA representatives of Airports, ATC, Standards, Satellite Navigation, and Research and Acquisition as well as representatives of industry and the operator community.”

According to the pilots surveyed some increased level of IFR support is necessary, but not to the degree that the white paper is recommending.

4.2.7 LOAs for SVFR Operations

Each of the operators was very familiar with the LOA and individual requirements to operate SVFR within the designed airspace for both the study airports and individual airports to which they fly (Section 2.7.1.5). Each LOA is required to be signed by the facility and each operator to whom it applies. It lays out the purpose, scope, responsibility, and procedures for SVFR operation. LOAs are actively supported by all parties and have significantly improved rotorcraft operations in marginal meteorological conditions.

5.0 RECOMMENDATIONS

These recommendations are the result of analysis and review of current ATC procedures, interviews with ATC personnel at the four study facilities, and telephone interviews with local rotorcraft operators that routinely transit the study airspace. This investigation clearly demonstrates the need for development of SNI procedure in high volume areas to some level.

5.1 Action Items

The following is a list of action items identifying further work that must be accomplished to define an SNI operations concept and provide the groundwork for development.

- **Employ public-private cooperation to advance development and implementation of SNI efforts.**

  As the aviation environment continues to evolve, issues of delay and capacity remain at the forefront. Serious institutional changes need to be made. As the cost of building new facilities or adding new landing surfaces continues to escalate, it becomes more and more necessary that the responsibility of finding a solution be shared. Both government and industry need to apply a practical approach when addressing issues associated with rotary-wing aircraft. Recent successes in public-private partnerships that accomplish what were once strictly government projects have paved the way for future applications of this method. Examples of successes are development of non-precision GPS rotorcraft criteria, NASA AGATE program, and active tracking of aircraft during the 1996 Olympics as part of Operation Heli-STAR. Partnerships have provided a vehicle where all participants win. Those involved must be dedicated and committed to work together to ensure success of individual efforts. Without this type of proactive partnership success is doubtful.

- **Encourage operator involvement in all development and application of SNI procedures.**

  There is a positive commitment from the national rotorcraft support organizations and government to develop a safe and efficient vertical flight infrastructure as recommended in the white paper, "Developing a Safe and Efficient Vertical Flight Infrastructure". Based on the ATC and pilot interviews, enthusiasm for this effort has not filtered down to the operations level. Operators do believe some increase of IFR support is necessary at this time, but not to the same degree.

  Undertaking development of an SNI operational environment has merit, but success of the program can only be measured by the individuals who will use the system. Use of such a system will depend on how practical it is to the operator. Therefore, any development of an SNI concept must start with accurately defined need at the operator level. It would be ill advised to design and develop a national network only to find that no one wants to use it, as experienced with the Northeast Helicopter Corridor. Although well intended, the lack of radar coverage, limited public-use heliport approaches, and no transition routes, significantly limited its effectiveness. Planning and development needs to include all participants in order to thoroughly understand what is needed and what will be used.

- **Clearly define all aspects of a low altitude structure throughout the planning phase to match current operational requirements.**

  A separate "low altitude" structure that would support an SNI concept needs to be carefully defined. There are major points of contention regarding which low altitudes can be supported in an SNI network. Again, problems with the Northeast Helicopter Corridor route structure are a good example. Assigned altitudes ranged from as low as 1,700 feet AGL to a maximum of 5,000 feet MSL, with the result that, at best, radar coverage was limited throughout the corridor. Discussion with local rotorcraft operators revealed that 1,700 feet is considered a high altitude and they often fly as low as 500 feet AGL. Their opinion favored altitudes between 500 feet to 1,000 feet AGL to be where instrument operations should occur.

- **Use the successes and shortcomings of the Northeast Helicopter Corridor as a guide for developing an SNI low altitude network.**

  The Northeast Helicopter Corridor remains in effect for the most part. By examining it in detail and assessing the operational needs of both ATC and rotorcraft operators, procedures that are more applicable can be initiated for a prototype SNI network.

  Navigation technology has significantly improved since the late 1970's and early 1980's when the Northeast Helicopter Corridor was conceived. Satellites are routinely augmenting VFR navigation as demonstrated in the VFR test route and are steadily becoming a necessity for instrument flight. Other advances in technology offer a variety of possible solutions for navigation at the low altitudes where rotorcraft want to fly under IFR. The potential benefit of using these improved technologies for surveillance of low altitude operation should be investigated further.

- **Design a prototype research network based on GPS technology to evaluate the feasibility of a GPS SNI network.**

  The navigational accuracy that will be required to support an SNI concept should be based on GPS technology. However, the application of GPS as the sole means of navigation throughout any SNI structure is not currently feasible. Progress by the FAA to develop and field the LAAS and WAAS must be monitored closely. The FAA is currently projecting to commission Phase I of the WAAS by September of 2000. A prototype research network should be developed in concert with the FAA test program to evaluate feasibility of a GPS-based point-to-point SNI network.

- **Fund a public-private aeronautical research effort as a follow-on to the STI to develop and place a public-use non-precision GPS SIAP at one of the study airports.**

  There are no stand-alone rotorcraft public-use SIAPs. All available IFR procedures provide approaches in and out of an airport aligned to a runway. This forces the rotorcraft to compete with fixed-wing aircraft for a slot in the IFR flow. With the recent publication of the FAAO 7260.42, "Helicopter Non-Precision Approach Criteria Utilizing the Global Positioning System (GPS)", it is now possible to develop a stand-alone non-precision instrument procedure that can remove rotorcraft traffic from the fixed-wing IFR flow because it would not be necessary for the rotorcraft to align with a runway to land. PinS procedures that are removed from the immediate vicinity of the runway environment allow rotorcraft to execute an instrument procedure to a point, then proceed visually to a landing site whether on or off airport. The first phase of SNI development must provide for independent SIAP to remove rotorcraft from the standard IFR flow.

Recent success in the development of private-use non-precision GPS SIAPs serves to reinforce this recommendation. STI has been very successful in developing private-use SIAP for a variety of customers. Furthermore, working with ATC, they have been able to network together a variety of private GPS SIAPs to form a quasi low-altitude GPS network. Although these are not public-use procedures and the private sector has limited use, they provide test network of what can be developed. An aeronautical research effort should be funded as a follow-on to the work performed by STI to develop and place a public-use non-precision GPS SIAP at one of the study airports. This would provide a test base around which future SNI work could be developed.

- **Revisit TEC procedures to incorporate additional and modified rotorcraft direct routing through a liaison with the FAA.**

  As the next generation of rotorcraft procedures begin to take shape, it will be necessary to ensure that ATC services are fully available. The current TEC procedures should be revisited to incorporate additional and modified rotorcraft routing. An aeronautical research effort must include a liaison with the FAA to ensure network services are provided and maintained as part of the continuing SNI development.

- **Expand investigation to include 14 CFR Part 121 and regional air carriers.**

  Interviews for this effort focused on ATC facilities and designated rotorcraft operators within the study area. As part of any future effort, CFR Part 121 and regional air carriers should be included in the investigative process. Their perspective on operational issues is a missing part that should be included in any future assessment of terminal and en route area of PHL and N90.

- **Continue recognition and cooperation with local communities on environmental issues, particularly noise.**

  In developing any procedure, whether visual or instrument, there are a variety of environmental concerns that need to be addressed with the understanding that noise is always at the forefront of community rotorcraft concerns. Changing or re-directing an approach or departure path can have a significant impact on community noise. Although the current policy of all parties involved is to maintain the highest priority on environmental issues, noise must remain at the top of the list. As part of any SNI development, the needs of the community, as well as, those of aviation must be addressed.

5.2 Supplementary

A variety of studies have been conducted over the years to investigate ATC alternatives for rotorcraft that have addressed delay, congestion, capacity, and training requirements. During the course of this investigation one of the most frequently asked questions from both operators and ATC was, “Another study, what can we expect from this one?” Their feelings and sentiment was extremely clear. The individuals who handle the day-to-day operations, both ATC personnel and helicopter operators, rarely see the results of their contribution to the many investigative efforts. An avenue needs to be opened to provide feedback to the numerous participants, so that they learn and understand the outcome of their efforts.

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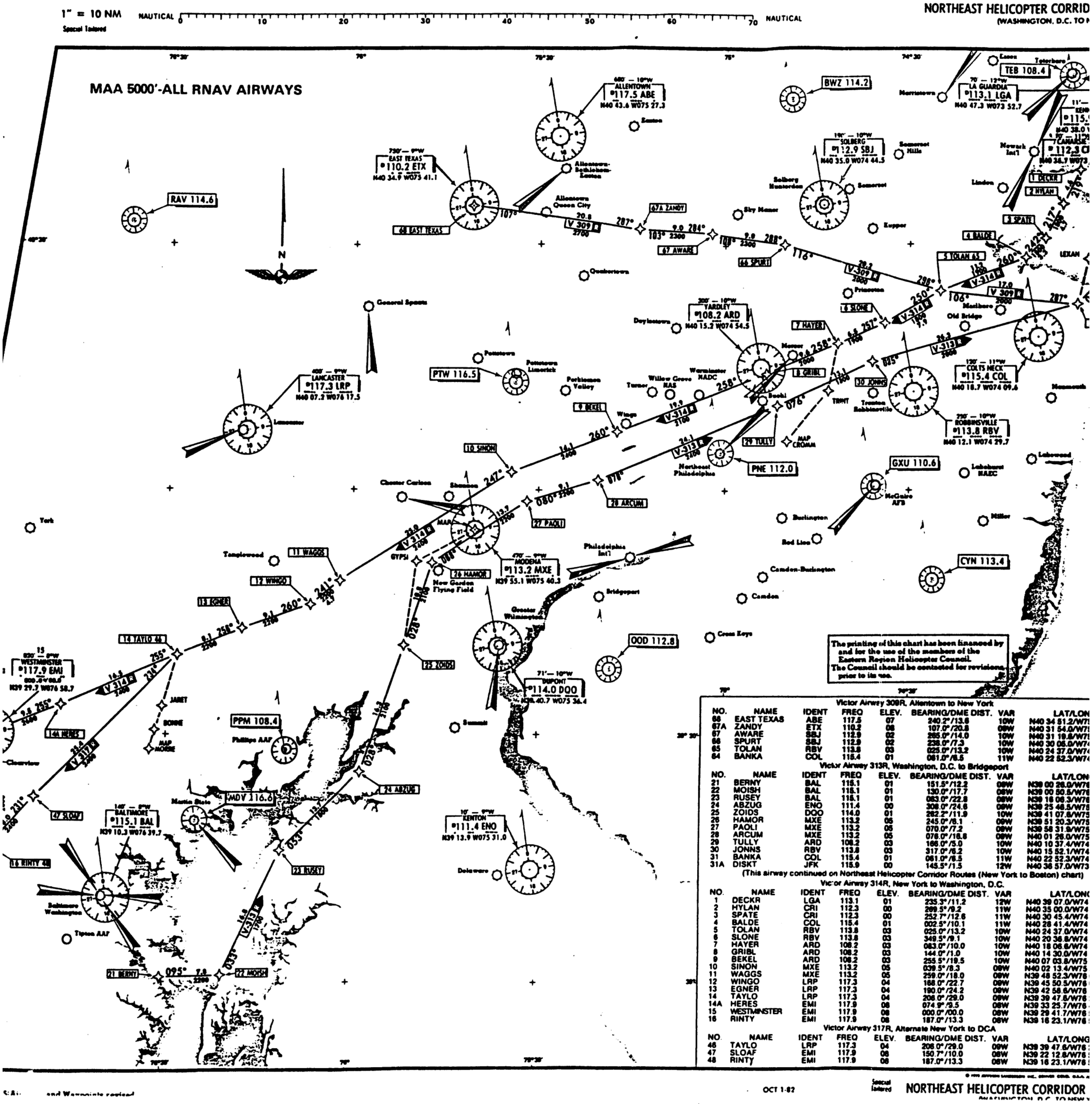
LIST OF ACRONYMS

CFR	Code of Federal Regulations
ADS-B	automatic dependent surveillance – broadcast
AGL	above ground level
AHS	American Helicopter Society
AIM	Aeronautical Information Manual
ARTCC	air route traffic control center
ASR	airport surveillance radar
ATC	air traffic control
ATCT	air traffic control tower
ATS	air traffic control service
BOS	Boston Logan International Airport
CETF	Capacity Enhancement Task Force
DH	decision height
EMS	emergency medical service
ERHC	Eastern Region Helicopter Council
EWR	Newark International Airport
FAA	Federal Aviation Administration
FAAO	Federal Aviation Administration Order
FBO	fixed base operator
FTE	flight technical error
GA	general aviation
GPS	global positioning system
HAI	Helicopter Association International
Heli-STAR	Helicopter Short-Haul Transportation and Aviation Research
HPN	White Plains Airport
IFR	instrument flight rule
ILS	instrument landing system
IMC	instrument meteorological conditions
JFK	John F. Kennedy International Airport
JHU/APL	Johns Hopkins University Applied Physics Laboratory
LAAS	local area augmentation system
LGA	LaGuardia Airport
LOA	letter of agreement
MAHA	Mid-Atlantic Helicopter Association
MOU	memorandum of understanding
MSL	mean sea level
N90	New York TRACON
NAR	National Airspace Review
NAS	national airspace system
NAVAIDS	navigation aids
NEHPA	New England Helicopter Pilot's Association
nm	nautical mile
NWS	National Weather Service
PHL	Philadelphia International Airport
PinS	point-in-space
R&D	research and development
RAIM	receiver autonomous integrity monitoring
RNAV	area navigation
SIAP	standard instrument approach procedure
SID	standard instrument departure

SNI	simultaneous non-interfering
STAR	standard arrival routes
STC	supplemental type certificate
STI	Satellite Technologies Implementation
SVFR	special VFR
TANAAC	Teterboro Aircraft Noise Abatement Committee
TEB	Teterboro Airport
TEC	tower en route control
TERPS	terminal instrument procedures
TRACON	terminal radar approach control
VFR	visual flight rules
VOR	very high frequency omni-directional range
VOR/DME	very high frequency omni-directional range/distance measuring equipment
WAAS	wide area augmentation system

APPENDICES

APPENDIX A



Victor Airway 309R, Allentown to New York

NO.	NAME	IDENT	FREQ	ELEV.	BEARING/DME DIST.	VAR	LAT/LON
68	EAST TEXAS	ABE	117.5	07	240.2°/13.6	10W	N40 34 51.2/W7
67A	ZANDY	ETX	110.2	08	107.0°/20.8	09W	N40 31 54.0/W7
67	AWARE	SBJ	112.9	02	285.0°/14.0	10W	N40 31 19.8/W7
66	SPURT	SBJ	112.9	02	238.0°/7.3	10W	N40 30 06.0/W7
65	TOLAN	RBV	113.8	03	025.0°/13.2	10W	N40 24 37.0/W7
64	BANKA	COL	115.4	01	061.0°/6.5	11W	N40 22 52.3/W7

Victor Airway 313R, Washington, D.C. to Bridgeport

NO.	NAME	IDENT	FREQ	ELEV.	BEARING/DME DIST.	VAR	LAT/LON
21	BERNY	BAL	115.1	01	151.5°/12.2	08W	N39 00 26.0/W7
22	MOISH	BAL	115.1	01	130.0°/17.7	08W	N39 00 50.5/W7
23	RUSEY	BAL	115.1	01	083.0°/22.8	08W	N39 16 06.3/W7
24	ABZUG	ENO	111.4	00	308.0°/24.6	09W	N39 25 46.5/W7
25	ZOIDS	DQO	114.0	01	282.2°/11.9	10W	N39 41 07.6/W7
26	HAMOR	MXE	113.2	05	245.0°/6.1	09W	N39 51 20.3/W7
27	PAOLI	MXE	113.2	05	070.0°/7.2	09W	N39 58 31.9/W7
28	ARCUM	MXE	113.2	05	076.0°/16.8	09W	N40 01 26.0/W7
29	TULLY	ARD	108.2	03	166.0°/5.0	10W	N40 10 37.4/W7
30	JONNS	RBV	113.8	03	317.0°/6.2	10W	N40 15 52.1/W7
31	BANKA	COL	115.4	01	061.0°/6.5	11W	N40 22 52.3/W7
31A	DISKT	JFK	115.9	00	145.5°/1.5	12W	N40 36 57.0/W7

(This airway continued on Northeast Helicopter Corridor Routes (New York to Boston) chart)

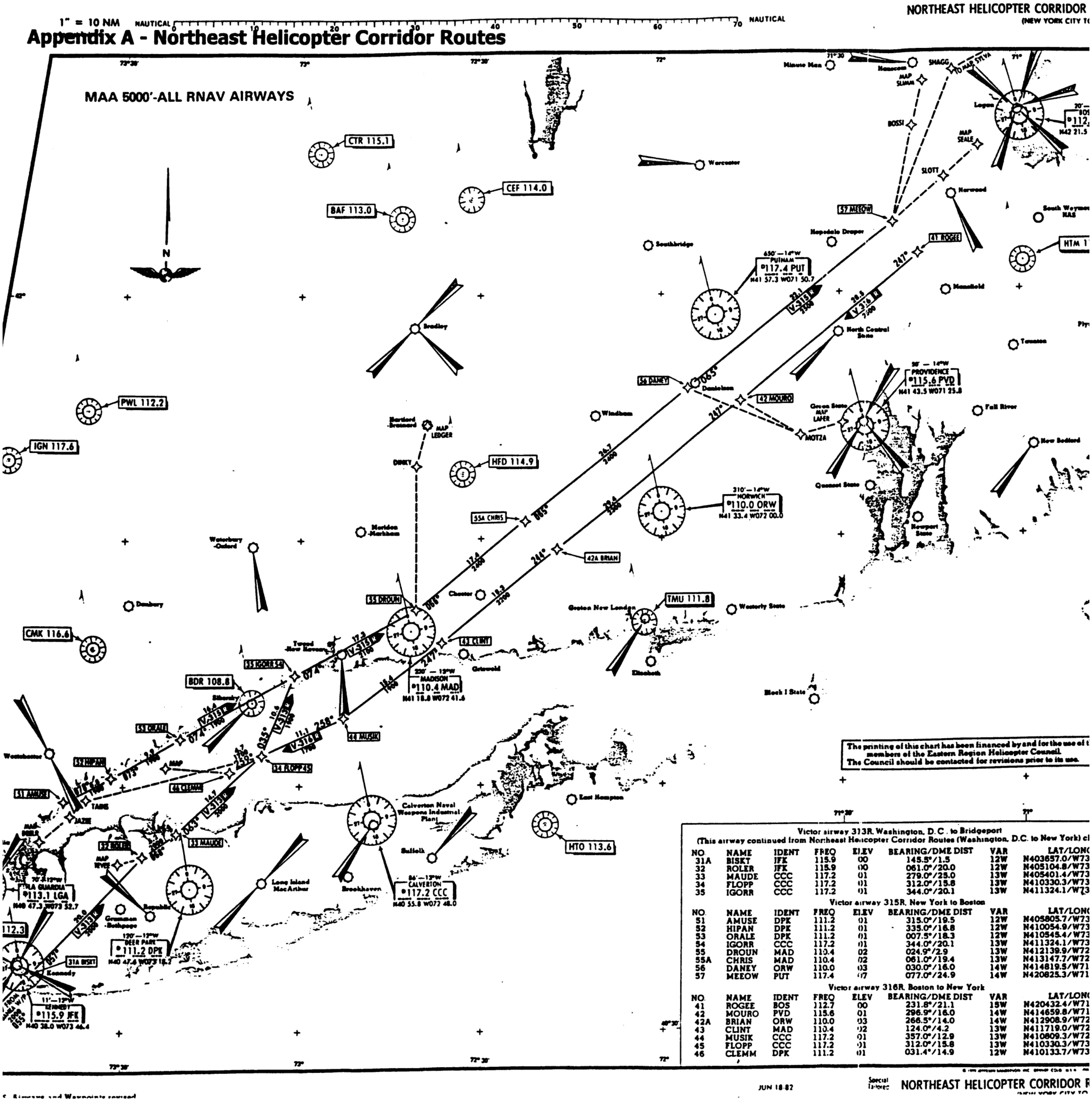
Victor Airway 314R, New York to Washington, D.C.

NO.	NAME	IDENT	FREQ	ELEV.	BEARING/DME DIST.	VAR	LAT/LON
1	DECKR	LGA	113.1	01	235.3°/11.2	12W	N40 39 07.0/W7
2	HYLAN	CRI	112.3	00	269.5°/9.2	11W	N40 35 00.0/W7
3	SPATE	CRI	112.3	00	252.7°/12.6	11W	N40 30 45.4/W7
4	BALDE	COL	115.4	01	002.5°/10.1	11W	N40 28 41.4/W7
5	TOLAN	RBV	113.8	03	025.0°/13.2	10W	N40 24 37.0/W7
6	SLONE	RBV	113.8	03	349.5°/9.1	10W	N40 20 36.8/W7
7	HAYER	ARD	108.2	03	083.0°/10.0	10W	N40 18 06.6/W7
8	GRIBL	ARD	108.2	03	144.0°/1.0	10W	N40 14 30.0/W7
9	BEKEL	ARD	108.2	03	255.5°/19.5	10W	N40 07 03.8/W7
10	SINON	MXE	113.2	05	039.5°/8.3	09W	N40 02 13.4/W7
11	WAGGS	MXE	113.2	05	259.0°/18.0	09W	N39 48 52.3/W7
12	WINGO	LRP	117.3	04	168.0°/22.7	09W	N39 45 50.5/W7
13	EGNER	LRP	117.3	04	190.0°/24.2	09W	N39 42 58.6/W7
14	TAYLO	LRP	117.3	04	206.0°/29.0	09W	N39 39 47.8/W7
14A	HERES	EMI	117.9	08	074.9°/9.5	08W	N39 33 25.7/W7
15	WESTMINSTER	EMI	117.9	08	000.0°/00.0	08W	N39 29 41.7/W7
16	RINTY	EMI	117.9	08	187.0°/13.3	08W	N39 16 23.1/W7

Victor Airway 317R, Alternate New York to DCA

NO.	NAME	IDENT	FREQ	ELEV.	BEARING/DME DIST.	VAR	LAT/LONG
46	TAYLO	LRP	117.3	04	206.0°/29.0	09W	N39 39 47.6/W7
47	SLOAF	EMI	117.9	08	150.7°/10.0	08W	N39 22 12.8/W7
48	RINTY	EMI	117.9	08	187.0°/13.3	08W	N39 16 23.1/W7

Appendix A - Northeast Helicopter Corridor Routes



Victor airway 313R. Washington, D.C. to Bridgeport
(This airway continued from Northeast Helicopter Corridor Routes (Washington, D.C. to New York) cl

NO.	NAME	IDENT	FREQ	ELEV	BEARING/DME DIST	VAR	LAT/LONG
31A	BISKT	JFK	115.9	00	145.5°/1.5	12W	N403657.0/W73
32	ROLER	JFK	115.9	00	061.0°/20.0	12W	N405104.8/W73
33	MAUDE	CCC	117.2	01	279.0°/25.0	13W	N405401.4/W73
34	FLOPP	CCC	117.2	01	312.0°/15.8	13W	N410330.3/W73
35	IGORR	CCC	117.2	01	344.0°/20.1	13W	N411324.1/W73

Victor airway 315R. New York to Boston

NO.	NAME	IDENT	FREQ	ELEV	BEARING/DME DIST	VAR	LAT/LONG
51	AMUSE	DPK	111.2	01	315.0°/19.5	12W	N405805.7/W73
52	HIPAN	DPK	111.2	01	335.0°/16.8	12W	N410054.9/W73
53	ORALE	DPK	111.2	01	007.5°/18.3	12W	N410545.4/W73
54	IGORR	CCC	117.2	01	344.0°/20.1	13W	N411324.1/W73
55	DROUN	MAD	110.4	02	024.9°/2.9	13W	N412139.9/W72
55A	CHRIS	MAD	110.4	02	061.0°/19.4	13W	N413147.7/W72
56	DANEY	ORW	110.0	03	030.0°/16.0	14W	N414819.5/W71
57	MEEOW	PUT	117.4	07	077.0°/24.9	14W	N420825.3/W71

Victor airway 316R. Boston to New York

NO.	NAME	IDENT	FREQ	ELEV	BEARING/DME DIST	VAR	LAT/LONG
41	ROGEE	BOS	112.7	00	231.8°/21.1	15W	N420432.4/W71
42	MOURO	PVD	115.6	01	296.9°/16.0	14W	N414659.8/W71
42A	BRIAN	ORW	110.0	03	266.5°/14.0	14W	N412908.9/W72
43	CLINT	MAD	110.4	02	124.0°/4.2	13W	N411719.0/W72
44	MUSIK	CCC	117.2	01	357.0°/12.9	13W	N410809.3/W72
45	FLOPP	CCC	117.2	01	312.0°/15.8	13W	N410330.3/W73
46	CLEMM	DPK	111.2	01	031.4°/14.9	12W	N410133.7/W73

VS-99-007
January 1999
M8A01
REVISED

Sponsor: Mr. J. R. Ryan
Air Transport Association
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Washington, DC 20004-1707

GPS RISK ASSESSMENT STUDY

FINAL REPORT

THE JOHNS HOPKINS UNIVERSITY • APPLIED PHYSICS LABORATORY
11100 Johns Hopkins Road, Laurel, Maryland 20723-6099
Operating Under Contract 98-JHU-01 With the Air Transport Association

VS-99-007
January 1999
REVISED

GPS RISK ASSESSMENT STUDY

FINAL REPORT

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ABSTRACT

The Federal Aviation Administration (FAA) has initiated plans to transition from its present ground-based navigation and landing system to a satellite-based system using signals provided by the Department of Defense's Global Positioning System (GPS). However, GPS alone will not meet all aviation positioning requirements. To meet the National Airspace System (NAS) requirements, the FAA has proposed two augmentations to GPS: a Wide Area Augmentation System (WAAS) and a Local Area Augmentation System (LAAS). There have been expressions of concern regarding the robustness of this plan and whether the risks to dependence upon GPS have been adequately addressed. In response to this concern, the FAA, with co-sponsorship from the Air Transport Association (ATA) and the Aircraft Owners and Pilots Association (AOPA), issued a request for an impartial study. The Johns Hopkins University Applied Physics Laboratory (JHUIAPL) was selected to conduct that study, which is the subject of this report.

The report quantifies the ability of GPS, GPS/WAAS, and GPS/LAAS to satisfy Required Navigation Performance (RNP) as expressed by accuracy, integrity, continuity, and availability requirements. Additional navigation options that mitigate the identified risks were also evaluated. In particular, these options included potential improvements to the GPS Standard Positioning Service (SPS) and additional capabilities onboard the aircraft such as integration of additional sensors and application of GPS anti-jam technologies.

KEYWORDS: National Airspace System
Global Positioning System
Navigation

EXECUTIVE SUMMARY

ES.1 PERFORMANCE

An independent risk assessment was conducted by the Johns Hopkins University Applied Physics Laboratory (JHU/APL) to determine if the Global Positioning System (GPS) and augmented GPS can satisfy the performance requirements to be the only navigation system installed in an aircraft and the only service provided by the Federal Aviation Administration (FAA) for operations anywhere in the National Airspace System (NAS). This report quantifies the ability of GPS, GPS with the Local Area Augmentation System (LAAS), and GPS with the Wide-Area Augmentation System (WAAS) to satisfy navigation performance requirements as expressed by accuracy, integrity, continuity, and availability requirements. Oceanic through Category III Precision Approach operations were evaluated with risks that present both normal and abnormal degrees of performance degradations. The primary conclusion is that GPS must be augmented to meet these requirements and that WAAS/LAAS can provide the required navigation performance. The study considered all known risks and its primary conclusion assumes the identified mitigation actions are instituted, and specific WAAS/LAAS configurations are implemented. The main conclusions of the study are as follows:

a. GPS with appropriate WAASILAAS configurations can satisfy the required navigation performance as the only navigation system installed in the aircraft and the only navigation service provided by the FAA.

b. Risks to GPS signal reception can be managed, but steps must be taken to minimize the effects of intentional interference.

c. A definitive national GPS plan and management commitment is needed to establish system improvements with civil aviation users and to provide greater informational access to the civil aviation community.

In particular, the final conclusion points to the need to develop a combined GPS and augmentations system design based on cost and performance trades among GPS system improvements, GPS operational policies, and WAAS/LAAS capabilities. Study findings with regard to the three system configurations considered are summarized in the following subsections.

ES.1.1 SATELLITE CONSTELLATIONS

Currently, 27 GPS satellites are operating. They provide the minimum basic configuration of 24 satellites (6 orbit planes of 4 satellites each) and 3 active on-orbit spares. The number of operating satellites could slip to 24 before additional replacements are added. In this study, the current constellation is assumed to be the nominal basic 24-satellite constellation (i.e.. 6 by 4). The next logical extension of this geometry would be a 30-satellite constellation (i.e., 6 by 5), and that geometry was considered to represent an expanded GPS constellation that might practically be implemented.

The current GPSIWAAS test configuration is based on the current GPS constellation supported by two geostationary satellites (GEOS). Therefore, the base constellation for GPS/WAAS analysis was 24 GPS satellites and the current 2 GEOS. Improvements considered expansions up to five GEOS. GPS/LAAS analyses were based on the minimum acceptable GPS/WAAS configuration— a 24-satellite and a 30-sateffite GPS constellation. Airport pseudolites (APLs) were also included to improve local geometry.

ES.l.2 GPS WITHOUT AUGMENTATION

A 24-satellite GPS constellation without augmentation cannot meet oceanic, en route, terminal, and nonprecision approach service requirements of the NAS. The removal of selective availability and/or the addition of a second civil frequency did not alter this finding. The best performance was achieved with a 30-satellite constellation (with selective availability off and a second civil frequency available), and even that configuration met the required levels of service for only oceanic navigation.

ES.1.3 GPS/WAAS

A GPS/WAAS configuration with 24 GPS satellites and 4 GEOS can satisfy all NAS positioning requirements from oceanic through Category I approach. This result did not require any specific improvements to the GPS satellites. Performance is sensitive to the ionospheric correction methods and further analysis is recommended to better optimize the WAAS configuration (i.e., number of GEOS and number of ground stations). It must also be noted that the current GEOS establishment and replacement plan is not yet clearly identified; this plan must be defined to ensure the required capabilities are provided.

ES.1.4 GPS/LAAS

A GPS/LAAS configuration based on a 30-satellite GPS constellation or one with 24 GPS satellites and 4 GEOS can satisfy all precision approach requirements. Some airports will require ground transmitters that act like additional GPS satellites (APLs) and/or improved GPS antennas and extra receivers to achieve the highest availability levels (i.e., >0.99999). This level of performance will require no GPS satellite improvements.

ES.l.5 PENDING GPS SIGNAL IMPROVEMENTS

Because the current augmentation designs are responsive to the current GPS satellite signal conditions, the removal of selective availability and the addition of a second civil frequency did not have a major impact on the cases analyzed for this study. However, the pending GPS signal improvements are very important to system robustness and to eventual cost savings and/or performance improvements of the final system.

Removal of selective availability greatly reduces the information rate required for the corrections provided by WAAS and LAAS, which reduces the communications burden. More importantly, removal of selective availability could allow the system to maintain acceptable performance even with a brief interruption of communications. With GPS/LAAS, for example, the corrections provided at the start of an approach would be valid throughout the approach.

As announced by Vice President Al Gore in March 1998, the secondary military frequency (1227.6 MHz) would have an added signal modulation that could be used for civil applications. However, the second frequency referred to in this report is required to be in a portion of the spectrum that is internationally allocated for aeronautical radio-navigation services. A White House press release on 25 January 1999 announced that agreement has now been reached on the addition of a new GPS frequency (1176.45 MHz) that will provide the second frequency capability needed to serve the NAS requirements.

The impact of the second civil frequency will completely remove the requirement for ionospheric corrections for users equipped to take advantage of this feature, and it will improve the corrections provided by WAAS. If, at some future time, the full community were to shift to dual-frequency user equipment, the WAAS ground station requirements could be reduced significantly. The density of WAAS reference stations required for ionospheric correction is greater than that required for orbit determination or for integrity monitoring. Furthermore, the second civil frequency, and the proposed higher signal power, will mitigate interference concerns.

ES.2 RISKS

The only risks that proved significant are interference (unintentional and intentional) and ionospheric propagation effects (high sunspot cycle and scintillation); these risks are discussed in the following subsections.

ES.2.1 UNINTENTIONAL INTERFERENCE

Although there have been few reports of GPS receiver interference from the many Government and commercial transmitters currently operating in the NAS, a review of interference sources identified in RTCA DO-235 indicates that several have the potential for GPS signal disruption. Three potential interference sources were singled out for further analysis. The first and potentially most serious one is television broadcast. The current Federal Communications Commission (FCC) specifications allow out-of-band emissions of sufficiently high levels to interfere with GPS signal reception. A simulation effort, undertaken to evaluate television emissions, indicated that stations transmitting on channel 23 within line of sight of aircraft approach paths could readily deny GPS signal reception. However, this threat is easily managed by modifying television broadcast regulations to exclude unacceptable power levels in satellite radio-navigation bands, by testing for interference when FAA instrument approaches are first established, and by adding filtering to the television transmitter output that are found to interfere with GPS reception.

The second area of concern is commercial very high frequency (VHF) broadcast (e.g., taxi dispatch). The levels of power and typical antenna configurations restrict this threat to small regions near runways. VHF broadcast interference would also be managed by the same measures indicated for television broadcast.

The third possible threat is from over-the-horizon (0TH) military radar. 0TH radar interference was not analyzed because insufficient information was available during this study. This threat is very restricted with regard to number and geography; therefore, it is not expected to be a significant risk. However, it is recommended that this emission source be further reviewed to ensure the risk is truly insignificant.

In summary, unintentional interference is not a major risk factor. Most interference difficulties reported by the aircraft community thus far have been the result of onboard interference, which is necessarily resolved during certification. While it is not possible to rule out future interference from offboard emitters, remedying such problems should not be difficult. The introduction of a second civil frequency will further reduce concerns about unintentional interference. Furthermore, the actions required to counter intentional interference will readily address this risk.

ES.2.2 INTENTIONAL INTERFERENCE

Intentional interference is by far the largest risk area; however, the planned avionics are designed to quickly recognize the onset of this threat. Assuming that sufficient resources are available to vector aircraft away from jammed regions, this threat will pose no safety risk. It can, however, create considerable disruption in traffic control and flight schedules. Methods to detect, locate, and prosecute those who intentionally jam GPS signals must be put in place to discourage such activities. Air traffic control procedures must also be established to manage affected aircraft. The study concludes that there is no credible spoofing threat and that, although real, jamming threats can be managed.

Further refinements of this analysis need to be based on specific threat definitions. The study was based on a threat the study team judged to be plausible with regard to economic and motivational characteristics. It is strongly recommended that the Department of Transportation (DOT), in cooperation with the intelligence community, establish specific threat definitions as a basis for further analysis.

Technologies are emerging that can greatly reduce vulnerability to GPS signal jamming. Techniques that can add 40 to 50 dB of additional rejection are possible; inclusion of such capabilities would virtually defeat the jamming threat considered in this study.

ES.2.3 LARGE IONOSPHERIC REFRACTION ERRORS

Considerable concern has been expressed about the impact of increased ionospheric refraction errors caused by spatial gradients during peaks of the sunspot cycle. A reasonable model of the ionosphere was created to evaluate this effect. It was found that errors produced did not significantly alter system performance for GPS only or LAAS, but did significantly degrade WAAS. It is important to note that the WAAS results regarding the larger ionospheric errors are sensitive to the ionospheric correction methodology. According to the definitions of the hazard risk index, its risk frequency is classified as “reasonably probable” and its consequence was considered “major” because of possible safety implications. With these classifications, the risk was determined to be “undesirable.” This risk can be mitigated by. increasing the density of the wide-area reference sites (WRSs) and/or grid points, as well as improving the ionospheric correction algorithm. This area of WAAS ionospheric correction methodology should receive further analysis, but it is JHU/APL’s judgement that the WAAS configuration can be designed to meet the needed performance so that risk becomes “acceptable.” However, note that when the second civil frequency becomes available, the risk is eliminated.

ES.2.4 IONOSPHERIC SCINTILLATION

Ionospheric scintillation is most severe in equatorial regions and in the auroral region. The most likely means by which ionospheric scintillation affects GPS users in the Continental United States (CONUS) is in viewing GPS satellites through these regions. The auroral region covers the northern part of Canada between 65° and 72° N *geomagnetic* latitude, and the equatorial region covers zones at 15° ± 10° N and at 15° ± 10° S geomagnetic latitude. Only the northern equatorial zone is seen from the United States and only by two of the locations included in the study.

A conservative model was used to test the overall impact of including this effect in the normal system availability analysis. Its impact was to drop the availability below requirements at a few locations. Therefore, ionospheric scintillation must be considered as a risk factor. According to the definitions of the hazard risk index, its risk frequency is classified as “reasonably probable” and its effect was judged to be “minor.” With these classifications, the risk is determined to be “acceptable” with FAA approval.

ES.3 <u>RECOMMENDATIONS</u>

The following subsections offer recommendations in three areas: GPS, WAASILAAS, and risk mitigation.

ES.3.l GPS

If civil aviation is to rely on GPS. greater access, cooperation, and agreement must exist on GPS operational control segment (OCS) procedures and future system performance. Specifically, the following must be addressed:

a. GPS operational procedures that support civil aviation policy need to be defined and implemented (e.g., signal monitoring, orbit management, and end-of-life operation and replacement strategies).

b. A means to convey full knowledge of failure rates and mechanisms that are essential to intelligent system design and operations must be established.

c. A process for Department of Defense (DOD) and DOT data collection and analysis must be established and sustained to characterize system performance and resolve incident reports (including international reports).

d. GPS specifications that reflect actual system performance and operational policies should be developed.

e. GPS coverage is currently limited by prediction of receiver autonomous integrity monitoring (RAIM) availability; current approaches are overly conservative by assuming all satellite failures are soft failures; and current algorithms are limited to "snapshot" position computations. These restrictions tend to increase reliance on the number of in-view satellites. Improvements to RAIM algorithms should be evaluated for possible cost reduction opportunities or performance improvements in the augmentation system structure.

These recommendations will allow sensible cost and performance trades between possible GPS system improvements and the implementation and operation of the augmentations supporting civil aviation. In support of these augmentations and to benefit the full domain of civil applications, a need exists to clearly define a national GPS plan that includes the following:

a. Establish a firm agreement on the size and characteristics of the satellite constellation and signal structures that will be maintained for all navigation services.

b. Specify the timetable for planned improvements (e.g., removal of selective availability and providing the second civil frequency).

ES.3.2 WAAS/LAAS

The following GPS/WAAS actions should also be taken to support development of a national GPS plan:

a. Establish the size and characteristics of the GEOS constellation that will be maintained to support civil aviation requirements. The plan will allow for the WAAS configuration to sensibly evolve and adapt in response to the availability of GPS satellite improvements. This study concluded that four GEOS are required to augment the current GPS satellite capabilities.

b. Further analyze, design, and validate the ionospheric correction methodology to support sizing of the ground reference station requirements and mitigation of the ionospheric risks discussed previously. Analyze possible robust receiver designs for mitigation of scintillation effects. Validate both analyses using National Satellite Test Bed (NTSB) and Phase 1 WRS data.

ES.3.3 INTERFERENCE RISKS

The following recommendations are directed at interference risks:

a. Develop regulations for all licensed transmitters that explicitly limit radio frequency (RF) emissions at satellite radio-navigation frequencies.

b. Require compliance monitoring of potential sources of satellite radio-navigation interference after maintenance or new construction.

c. Ensure that interference levels at satellite radio-navigation frequencies are measured during flight inspections at airports where GPS approaches are planned and where a potential unintentional interference threat exists.

d. Derive a DOT-authorized threat definition to support design of mitigation actions for intentional GPS signal interference.

e. Implement enforcement measures to discourage and remedy potential threats. Threat detection might be part of standard user aircraft reporting structure, but a separate airborne platform will be needed to locate the threat(s). This activity should naturally be coordinated with law enforcement agencies.

f. Develop traffic control procedures and provide training to overcome wide-area GPS signal outage caused by intentional interference.

g. Develop standards for onboard interference suppression system performance that address postulated threat(s), aircraft types, and postulated traffic control procedures.

h. Obtain measurements of underbody aircraft antenna gain and assess advantages of antenna locations to determine antenna pattern benefits.

i. Evaluate additional means for aircraft-based interference suppression. These might include antenna nulling and signal processing techniques and integration with inertial navigation instrumentation.

j. Review the risk of interference from military 0TH radar.

ES.4 LIMITATIONS

The conclusions and recommendations offered here represent sound engineering judgements that are backed by considerable analysis. The timeframe for this study required that certain approximations be made in lieu of comprehensive simulations. The study results are believed to be conservative; margins were applied in those areas where the models and/or data sources were limited. The following limitations should be noted:

a. AU performance analyses were based on snapshot measurement error statistics for an array of distributed geographic locations sampled every 5 mm throughout one repeat cycle of the GPS constellation (i.e., one sidereal day). While this approach is believed adequate to estimate aggregate performance, verification of performance should be based on higher fidelity trajectory simulation.

b. Full aircraft trajectory simulations were restricted to evaluating interference effects using typical landing conditions with an antenna pattern derived from limited data sources. The television interference model was necessarily based on a very small data set.

c. No data were available to characterize high-definition television interference levels at the GPS frequencies.

d. Although the receiver model used to support this study is believed to be a good representation of typical receivers, the study did not explicitly account for actual receiver performance differences that may exist among users.

e. GPSIWAAS performance estimates were based on making adjustments to models derived from NSTB data. No detailed simulation was constructed for this analysis.

f. The ionospheric scintillation model used for this study was simplified, but the model used is believed to conservatively bound reality.

g. Time-to-alert analyses could not be explicitly included within the simulation structure used for these studies. The augmentation system’s ability to meet these requirements was based on evaluations of the system design constraints provided by current descriptions and specifications.

Appendix C - N90 Proposed Reduced Separation Standards for GPS Equipped Helicopters

U.S. Department
of Transportation
Federal Aviation Administration

Memorandum

Subject: **INFORMATION:** Proposal For Reduced Separation Standards For GPS Equipped Helicopters

Date: FEB 5 1997

From: Air Traffic Manager, New York TRACON

Reply to Attn. of: Paul Greco:
516 683-2912
FAX:516 683-2946

To: Manager, Operations Branch, AEA-530

In February 1996, New York TRACON conducted a 120-day evaluation for helicopter routes proposed by the helicopter industry. These routes were evaluated to determine their affect on other traffic. Many times helicopter routes were not approved because of arrival and departure traffic, specifically for LaGuardia Airport (LGA). We reviewed controller input for route modifications based on LGA runway configurations; however, route design was limited because of prescribed radar/vertical separation standards from IFR aircraft separation from airspace boundaries and lateral/vertical separation from obstructions. We then examined the feasibility of IFR flight for GPS equipped helicopters using reduced separation criteria. Results indicated that the separation gave flexibility for route development. While not a panacea for all traffic situations, it would give terminal facilities (approach control and towers) a greater opportunity to determine the potential for helicopter routes through their airspace.

Attached are proposed Special GPS Navigation Standards for UPS equipped helicopters. We believe this proposal will help design helicopter routes in complex airspace and provide an acceptable level of safety for separation from traffic, airspace boundaries and obstructions.

Please review the subject matter and let me know of a suitable date to meet and discuss the proposal.

Loretta J. Martin

Attachment

SPECIAL GPS NAVIGATION ST~ARDS

Special GPS Navigation Standards (SGNS) involve reduced separation for IFR helicopters operating within a Designed Flight Track (DFT) from aircraft, airspace boundaries and obstacles/terrain in a radar environment.

NOTE. Per FAR. 91.119, helicopters may operate at less than the general minimums prescribed over congested areas and other than congested areas when the operation is conducted without hazard to persons or property on the surface. Additionally, each person operating a helicopter shall comply with any routes or altitudes specifically prescribed for helicopters by the Administrator.

Separation of aircraft is applied within a controller's area of jurisdiction.

DFT's are one mile in width and are made up of waypoints (WP) for pilot navigation to form an enroute structure. They may be developed using reduced separation criteria along airspace boundaries and from obstacles/terrain. Helicopters may file an IFR flight plan via a DFT as "GPS Helicopter Route (Number)".

A DFT may have one or more transitions which connect to other DFT's or reconnect to itself. Aircraft may be cleared via transitions because of traffic flows. Example: "Cleared via KINKK TRANSITION to WILDO resume own navigation."

Helicopters may be vectored off a DFT and subsequently vectored back on to a DFT for operational purposes. When doing so, the aircraft is advised of its position to the next waypoint it will fly over and to resume own navigation.

A DFT may be used to connect a helicopter enroute segment with an approach/departure course.

Example: A helicopter may use the approach course procedure as a departure procedure to intercept a DFT.

DFT's established using SGNS may link to non-radar routes. However, until review for non-radar application is completed, non-radar separation criteria per F~ Order 7110.65 shall apply within non-radar route segments.

SGNS SEPARATION:

a. Airspace edge of DFT may coincide with the boundary of adjacent airspace.

b. IFR Helicopter/Fixed Wing Aircraft:

1. Lateral separation:

(a) 1 1/2 miles from DFT;

(b) When transgressing a DFT, 3 miles from a helicopter operating within a DFT or applicable wake turbulence separation;

(c) 3 miles between IFR helicopters operating within a DFT; or,

2. Vertical separation: 1000 feet (500 feet between IFR helicopters operating within the same DFT or transgressing a DFT); or,

3. Visual separation: as specified in FAA Order 7110.65, para. 7-2-1, para. 7-4-2, and para. 7-6-7.

c. Between two DFT's, 1 mile and parallel from adjacent DFT.

d. Outside DFT, apply standard IFR separation criteria.

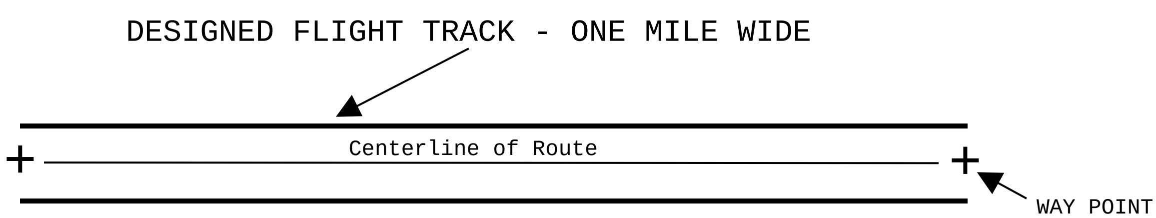
MINIMDM DFT ENRO~TE ALTITUDE: Lowest usable altitude along any portion of the DFT which is the higher of the following values:

a. At least 1,500 feet AGL rounded off to the nearest 100 feet; or,

b. 500 feet above an obstruction that is 2000 feet or less horizontally from a DFT then rounded up to the next 500 feet.

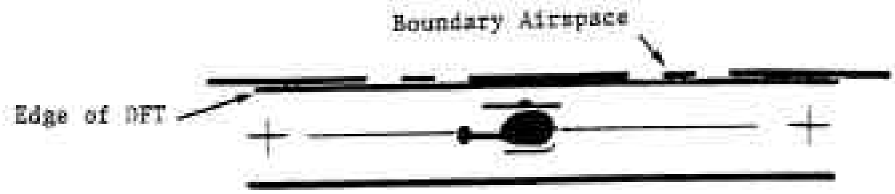
HOLDING: Helicopters operating within a DFT may be instructed to hold at a designated WP along the route. Ample notification is necessary for the aircraft to adjust speed to 9OKTS, so as to remain Within the DFT using 2W outbound leg lengths.

The following pictorials refer to separation standards used for helicopters that are GPS equipped and navigate within a Designed Flight Track (DFT). Chart representation of New York City is a illustration purposes only.
 A DFT within this airspace would require review and input from affected ATC facilities.

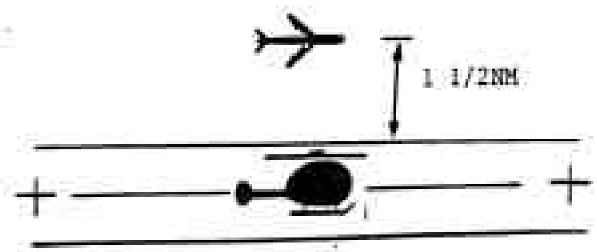


SGNS SEPARATION:

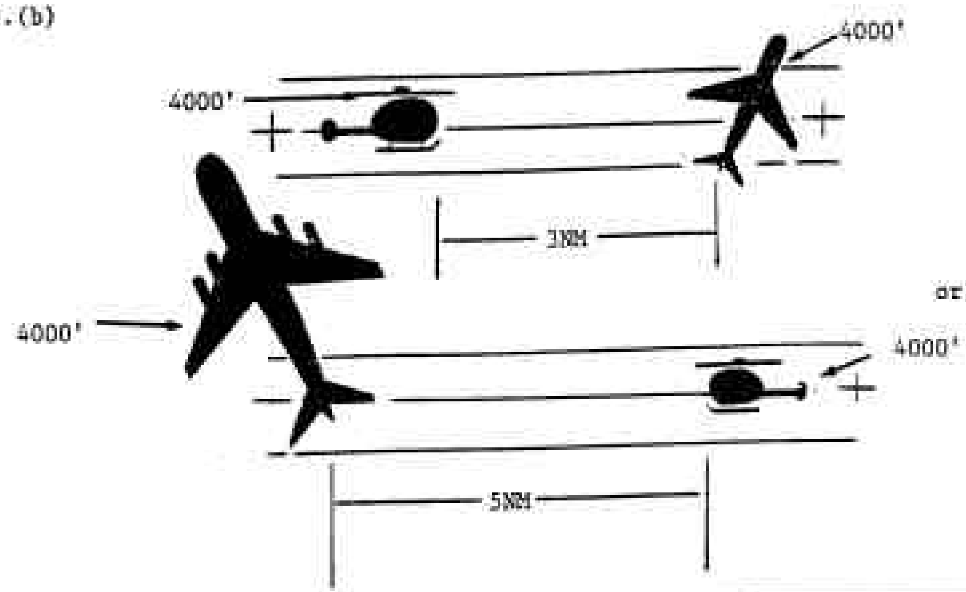
ra. a.



Para. b.1.(a)



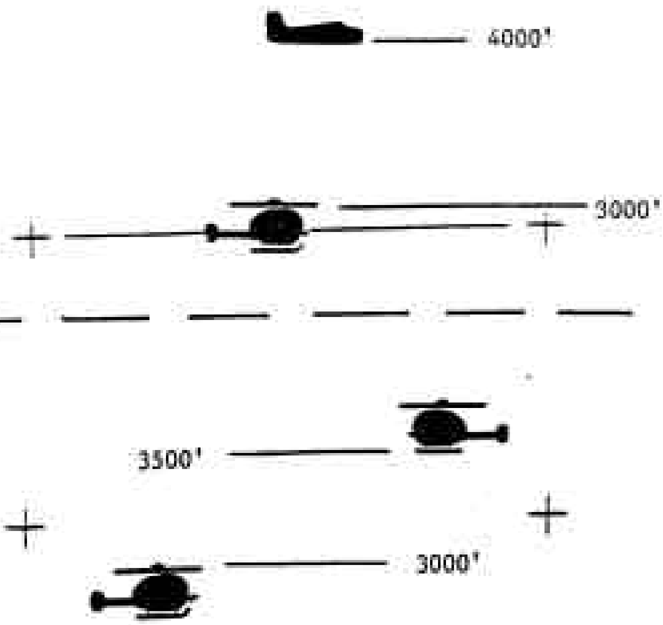
Para. b.1.(b)



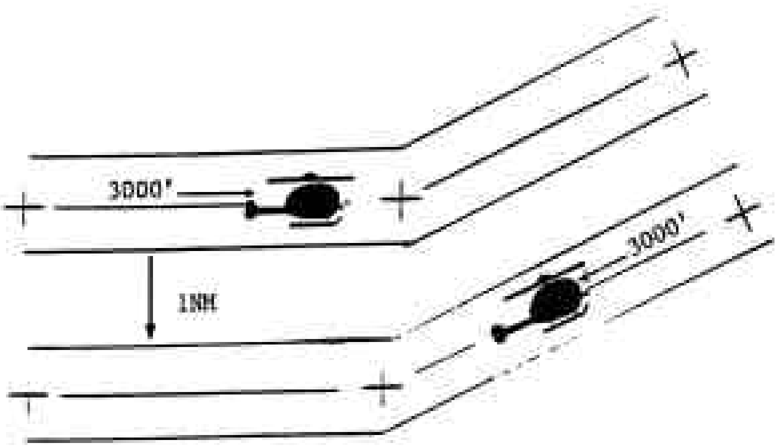
Para. b.1.(c)

SONS SEPARATION:

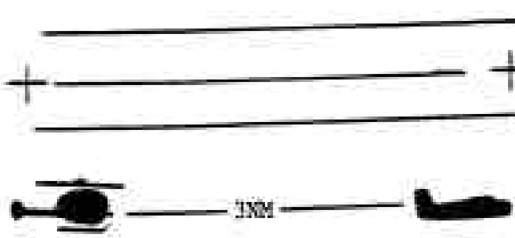
ra. b.2.

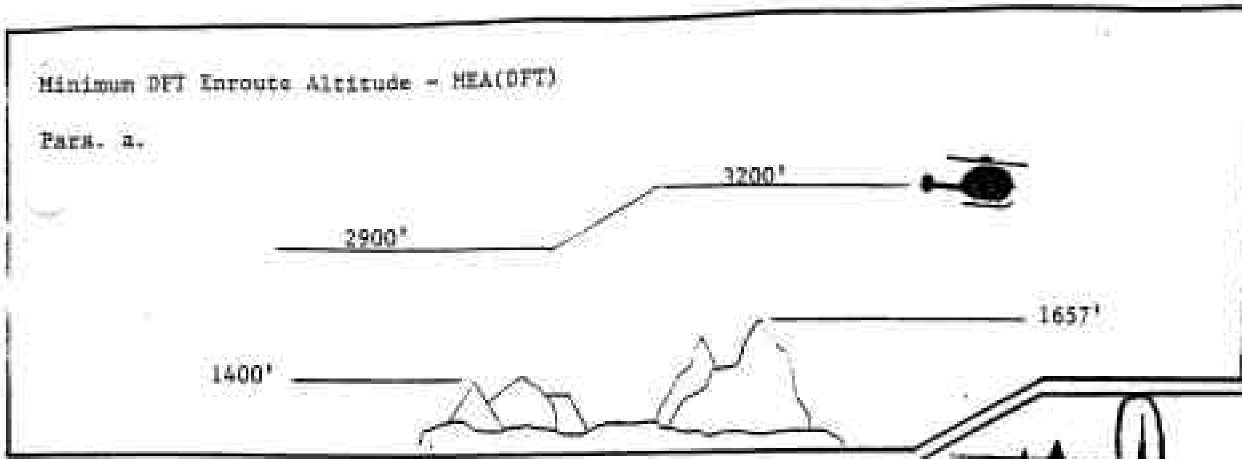


Para. c.



Para. d.

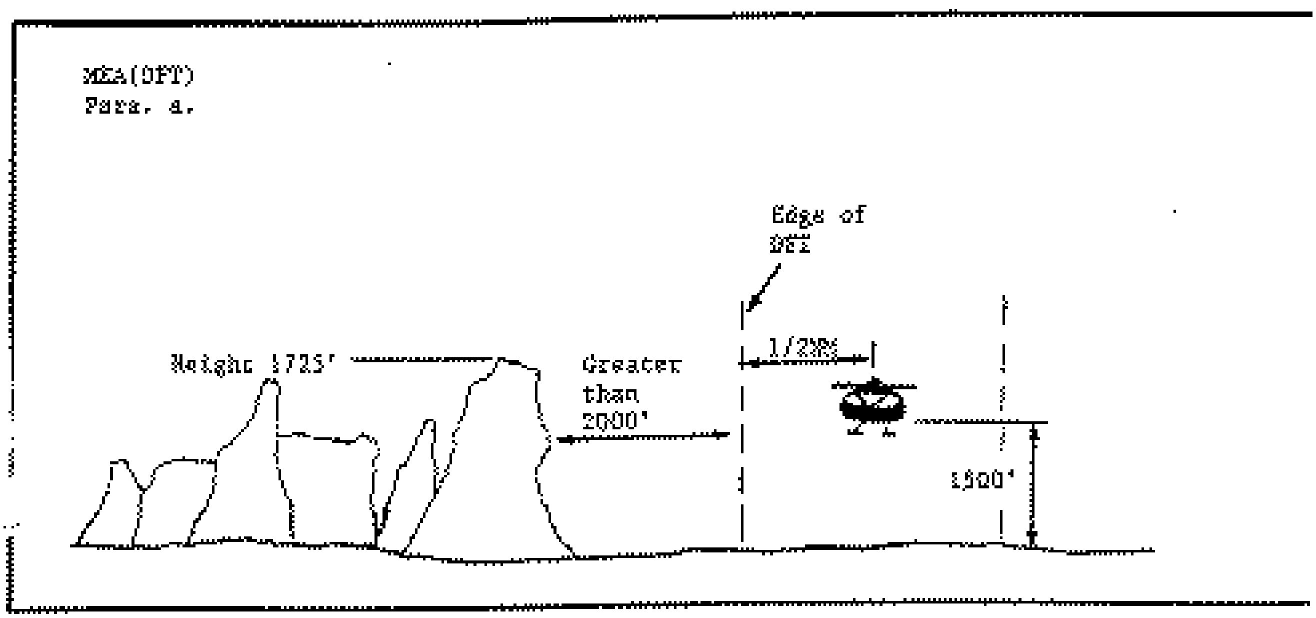




Minimum DFT Enroute Altitude - MEA(DFT)
Para. a.
3200'
2900'
1657'
1400'

MEA(DFT)
Para. a.
Altitude 2000'
INTREPID SEA AIR MUSEUM
1515
EMPIRE STATE BUILDING
326 bldg
516 bldg
737
UNITED NATIONS COMPLEX
WORLD TRADE CENTER
1742
BROOKLYN BRIDGE
GOVERNORS ISLAND

MEA(DFT)
Para. b.
Altitude 2500'
769
EMPIRE STATE BUILDING
1515
(1465)
737
(702)
647
(612)
H VILLAGE
339
(304)
350
(310)
516
(477)
338
(308)
BOWERY
AVENUE
17
CANAL
DELANCEY
ST
525
(510)
658
(630)
476
(435)
(Pvt)
HUDSON
WEST
SIDE
WORLD TRADE CENTER
825
ONE POLICE PLAZA
244
1742
(1730)
784
584
967
EXPRESSWAY
EAST RIVER


Para. a.
Edge of
Greater
than
2000'
1500'

Appendix D - Operator Questionnaire

QUESTIONNAIRE FOR HELICOPTER OPERATORS
NASA Task 17 SNI Investigation - Fall 1998

1. How often do you fly IFR (percentage)?

1a. What makes you decide to fly IFR or not?

1b. Why do you not fly IFR? Because there are constraints, or because you have no need to do so?

1c. If there constraints, what are they?

2. Do you fly the routes that are part of the Northeast Corridor?

3. Do you have letters of agreement with the FAA air traffic facilities?

3a. With whom? Why was this believed to be necessary?

3b. What do they specify?

4. What are your origins and destinations?

4a. What are the routes between the origins and destinations?

4b. What altitudes do you fly and why (noise abatement, icing, other)?

4. What airport in the New York area do you fly into?

5a. How often do you fly there?

5b. What percentage is IFR?

5c. Does the airport have a heliport/pad separate from the runways? Do you land there or on the runway?

5d. For IFR operations into this/these airports what is the approach procedure?

5e. For the approach, are you put in line with fixed-wing traffic, air carriers?

5f. For the approach, are there any conflicts with fixed-wing traffic, i.e., do you have to wait for fixed-wing, or they you?

5g. For IFR operations what is the departure procedure?

5h. For departure, are you put in line with fixed-wing traffic, air carriers?

5i. For departure, are there any conflicts with fixed-wing traffic, i.e., do you have to wait for air fixed-wing, or they you?

Appendix E - Letter of Agreement for LaGuardia

LaGuardia Tower and Signatories

LETTER OF AGREEMENT

Effective: 1/1/94

* SUBJECT: Helicopter Procedures for VFR and SVFR Flights Within The LaGuardia Tower Class B Surface Area.

* 1. **PURPOSE**: This agreement establishes procedures, conditions and responsibilities governing the operation and control of VFR and SVFR helicopters operated by the signatories within the LaGuardia Tower Class B Surface Area, and within that segment of the New York Class B Airspace for which LaGuardia Tower has been delegated responsibility. (See Attachment 1.)

2. **SCOPE**: LaGuardia Tower exercises control within a six nautical mile radius of LaGuardia VOR up to and including 2000 feet MSL.

3. **RESPONSIBILITIES**:

* a. Pilots are required to obtain authorization to enter the Class B Airspace/Surface Area, and the route to be flown. Authorization to leave the Class B Airspace/Surface Area does not constitute authority to re-enter the Class B Airspace/Surface Area without further clearance.

* b. Pilots shall obtain Automatic Terminal Information Service (ATIS) to prevent frequency congestion, and to determine weather conditions and airport traffic flows. Pilots shall advise the tower on initial contact that they have the current ATIS.

c. Pilots shall establish communications with LaGuardia Tower on 126.05 MHz or 119.95 MHz and shall maintain a continuous listening watch on that frequency at all times while under the control of LaGuardia Tower.

d. Pilots shall immediately inform LaGuardia Tower when a change to below basic VFR (ceiling 1000 feet/visibility 3 miles) conditions is anticipated, and shall remain in basic VFR conditions until an amended clearance is requested and received.

e. SVFR helicopters shall maintain visual reference to the surface and the traffic patterns, routes and reporting or holding points to facilitate separation as specified by LaGuardia Tower.

4. **PROCEDURES:**

a. Routes and altitudes shall be assigned by LaGuardia Tower.

*   b. Separation between helicopters within the Class B Airspace shall be the responsibility of the pilots when the weather is at or above basic VFR minimums.

c. Standard IFR separation will be provided by LaGuardia Tower when weather conditions fall below basic VFR minimums unless the operator is signatory to this agreement, establishing alternate SVFR separation minima by stating the word “SIGNA” in the request for clearance.

Alternate SVFR separation minima will apply as follows:

(1) Between two “SIGNA” helicopters - I mile.

(2) Between a “SIGNA” SVFR helicopter and an arriving or departing IFR aircraft when the IFR aircraft is less than one mile from the landing airport - 1/2 mile.

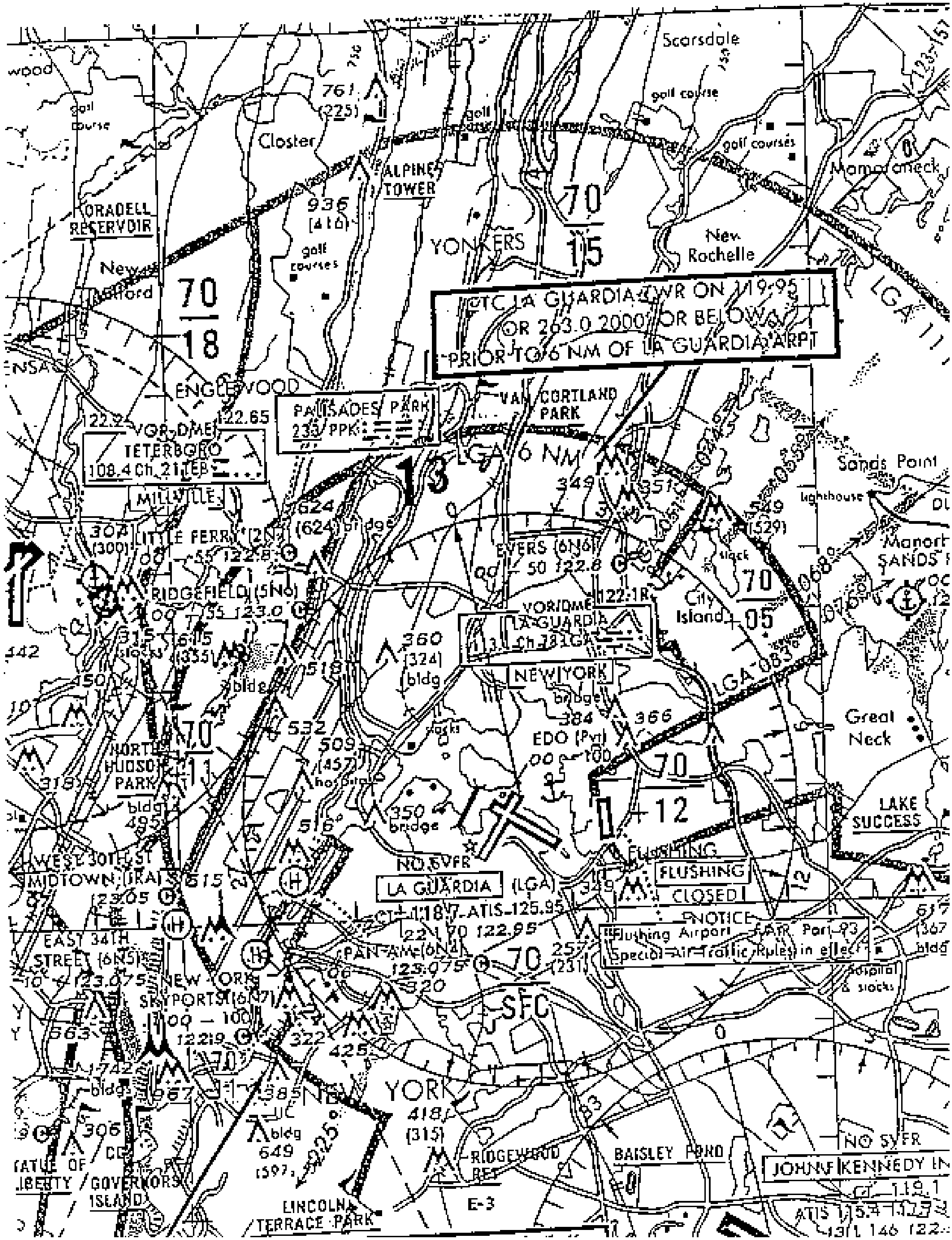
(3) Between a “SIGNA” SVFR helicopter and an arriving or departing IFR aircraft when the IFR aircraft is one mile or more from the airport - 1 mile.

d. Flight along any approved route shall be confined to within *114* mile of the prescribed track. Clearance may be issued from point-to-point or through several points. No orbiting is authorized without specific clearance from LaGuardia Tower. All VFR holding, either at an authorized point or a clearance limit, shall be accomplished within a 1/4 mile orbit.

NOTE: Nothing in this letter shall be construed to relieve aircraft operators from compliance with any applicable Federal, State, Municipal or airport regulations.
Nothing in this letter shall be construed to relieve aircraft operators from compliance with any applicable Federal, State, Municipal or airport regulations.

Ralph E. Kearns
Air Traffic Manager
LaGuardia Tower

Name:
Title:
Company Name:



Scarsdale
Closter
ALPINE TOWER
ORADELL RESERVOIR
YONKERS
New Rochelle
Mamaroneck
New Milford
70
18
70
15
CTC LA GUARDIA TWR ON 119.95 OR 263.0 2000' OR BELOW PRIOR TO 6 NM OF LA GUARDIA ARPT
ENGLEWOOD
PALISADES PARK
VAN CORTLANDT PARK
VOR-DME TETERBORO 108.4 Ch 21 TEB
LGA 6 NM
13
Sands Point
MILLVILLE
LITTLE FERRY (2N7)
EVERS (6N6)
RIDGEFIELD (5N0)
VOR/DME LA GUARDIA Ch 31 LGA
City Island
70
05
NEW YORK
Great Neck
EDO (Pvt)
NORTH HUDSON PARK
70
12
LAKE SUCCESS
WEST 30TH ST MIDTOWN (JRA)
NO SVFR
LA GUARDIA (LGA)
FLUSHING
FLUSHING CLOSED
NOTICE Flushing Airport FAR Part 93 Special Air Traffic Rules in effect
EAST 34TH STREET (6N5)
PAN AM (6N4)
NEW YORK SKYPORTS (6N7)
SFC
NEW YORK
RIDGEWOOD RES
BAISLEY POND
NO SVFR
JOHN F KENNEDY INTL
STATUE OF LIBERTY
GOVERNORS ISLAND
LINCOLN TERRACE PARK
E-3

AMERICAN HELICOPTER SOCIETY INTERNATIONAL
HELICOPTER ASSOCIATION INTERNATIONAL

DEVELOPING A SAFE AND EFFICIENT VERTICAL FLIGHT INFRASTRUCTURE

AWHITE PAPER

(AHS International and Helicopter Association International have developed the following White Paper, in association with industry and operator representatives, in response to the White House Commission on Aviation Safety and Security and Vice President Al Gore's challenge to improve safety of flight.)

Rotorcraft are an important, and growing, segment of the aviation community within the United States. Each year rotorcraft perform 9.6 million takeoffs and landings and fly approximately 2.3 million hours. The value of the fleet, flight hour expenditures, and manufacturer payrolls exceed $6.2 billion per year. Sales of rotorcraft for the commercial market are forecast to double during the next eight years, largely as a result of improvements in pure rotorcraft technology and the planned introduction of civil tiltrotor aircraft.

At the same time, the existing capacity of the airport and air traffic control system is strained as a result of rapid increases in air travel during the past decade. Forecasts show a further doubling of air travel during the next few years. Unless these conditions are addressed quickly, the consequences for the air transport industry and the traveling public will be higher cost, greater inconvenience, declining quality of service, and possibly diminished safety.

Development of an airport and airway infrastructure as part of the new National Airspace System to increase air system capacity and to accommodate simultaneous, non-interfering use by fixed-wing and rotary-wing aircraft is therefore a high national priority.

Vertical Flight Industry Goal: The development of air and ground infrastructure for rotorcraft operations based upon the concept of simultaneous non-interfering operations and heliport to heliport all weather operations through an FAA/industry partnership composed of an integrated product team, which includes FAA representatives of Airports, Air Traffic, Standards, Satellite Navigation, and Research and Acquisition as well as representatives of industry and the operator community.

Background: Instrument practices and procedures used in today's National Airspace System do not support safe and efficient vertical flight operations. Air traffic management systems now in use, based on the technologies of ILS ***(1943),*** VOR (1949), and ATC radar (1950s), were developed for fixed-wing aircraft operations prior to the introduction of the first IFR-capable helicopter in ***1964.*** These systems, designed for fixed-wing requirements, fail to recognize the three-dimensional flight capabilities and the flexibility of rotorcraft and thus contribute to needless delays and increased airside congestion for all aircraft using the national airspace system.

The lack of an adequate air transportation system for rotorcraft restricts flight operations, generates unnecessary costs, and adversely affects flight safety. Operators of helicopters experience a range of common problems. Examples include ***(1)*** circuitous routing by air traffic control; (2) excessive non-precision and precision approach minimums; (3) a lack of GPS precision approach procedures; (4) the lack of weather availability for alternates and destinations; (5) limited communications and surveillance capability at low altitudes; (6) an absence of procedures to minimize rotorcraft and fixed wing interaction in constrained airspace; and (7) overly restrictive requirements for heliport and vertiport design.

Collectively, these factors increase congestion and delays and reduce airspace capacity. They also encourage helicopter operators to fly beneath the weather in marginal conditions, thus creating an unsafe operating environment for all users of the national airspace system. Non-IFR operations in marginal weather limit the safety and protection that the air traffic control system customarily affords the aviation community.

These issues should be addressed by a FAA/Industry partnership through procedural change and technology development. For example, in recent years GPS and DGPS instrument approach development programs - the result of cooperative efforts by the FAA, the industry and the operator community - have achieved quick, inexpensive and responsive results.

<u>Recommendations</u>: The societies, joined by the industry and operator communities, endorse the concept of simultaneous and non-interfering operations (SNI) which includes heliport to heliport all-weather operations. SNI can increase the efficiency of rotorcraft operations and minimize interference between rotary-wing and fixed-wing aircraft operations in constrained airspace. Implementation of this concept through procedural change and technology development will result in additional capacity, reduced delay, improved safety, and efficient operations for commercial carriers, commuters, and general aviation.

To realize these benefits, we strongly recommend the creation of a FAA integrated product team, which includes operators and manufacturers, to develop and improve an appropriate air and ground infrastructure for rotorcraft operations. The group's initial goal should be the completion of the following SNI elements within the next twelve months using resources currently available to the government agencies and industry members:

- Complete the Special Category I (GLS or GPS Landing System) DGPS rotorcraft precision terminal procedures (TERPS) to enable near zero-zero approaches to a hover at heliports and airports (this work has already been initiated at Minneapolis and Newark airports).

- Complete implementation of the “GPS waypoint grid” for rotorcraft operations in the Gulf of Mexico; additionally, support the development of an Automated Dependent Surveillance Broadcast System (ADS-B) for offshore operations.

- Implement the GPS-based, low altitude IFR route structure developed for the Northeast corridor and initiate similar programs for other high traffic corridors.

- Develop and implement criteria for reducing route widths utilizing GPS technology.

- Update instrument approach procedure development criteria to allow one flight technical error data set to be used to determine the terminal procedures for a family of approach navigation systems, such as the Wide Area Augmentation System (WAAS), Local Area Augmentation System (LAAS) and GPS Landing System (GLS).

- Develop tiltrotor transition procedures, in conjunction with Department of Defense, to permit transition to and from low-high-low flight levels during flight operations.

- Streamline the development and approval process for infrastructure and procedures to permit the FAA and FM-designees to certificate GPS approaches.

- Develop a heliport/vertiport advisory circular that meets the needs of the rotorcraft community.

At the same time, government and industry should collaborate upon and launch the following SNI initiatives with the goal of completing them within the next 24 months:

- Develop tiltrotor specific GPS non-precision and precision approach terminal procedures to maximize tiltrotor capabilities.

- Establish criteria that allows high fidelity simulations to be used as the basis for draft terminal procedures development and credit simulation experience towards the required number of approaches to validate the terminal procedures.

- Develop and refine rotorcraft-inclusive air traffic management automation tools such as Center TRACON Automation System (CTAS), Final Approach Spacing Tool (Fast) and User Request Evaluation Tool (URET).

- Establish a vertical flight focal point within the Air Traffic System Requirements branch to ensure that vertical flight issues are addressed in terms of rotorcraft capabilities and concept of operations development.

—July ***1,*** 1998

STI News Release

STI was featured in Business & Commercial Aviation Magazine, February 1999 issue. Page 48. "Developing IFR Helicopter Infrastructure"

Click on date to bring up article

9 February, 1999	**HEADLINE: SATELLITE TECHNOLOGY IMPLEMENTATION (STD) DEVELOPS OVER ONE HUNDRED IFR "COPTER" GLOBAL POSITIONING SYSTEM (GPS) APPROACHES.**
16 October, 1998	**HEADLINE: IFR NETWORK OF SIX GLOBAL POSITIONING SYSTEM (GPS) APPROACHES WILL HELP SAVE LIVES FOR RURAL WISCONSIN.**
11 September, 1998	**HEADLINE: IFR NETWORK O NINETEEN GLOBAL POSITIONING SYSTEM (GPS) APPROACHES WILL HELP SAVE LIVES FOR RURAL OKLAHOMA**
5 September, 1998	**HEADLINE: SATELLITE TECHNOLOGY IMPLEMENTATION (STI) DEVELOPS GPS INSTRUMENT APPROACH PROCEDURES.**
15 February, 1998	**HEADLINE: THE FEDERAL AVIATION ADMINISTRATION RECOGNIZES SATELLITE TECHNOLOGY IMPLEMENTATION TO DEVELOP GLOBAL POSITIONING SYSTEM HELICOPTER INSTRUMENT APPROACHES.**
3 December, 1997	**HEADLINE: PRIVATELY DEVELOPED GLOBAL POSITIONING SYSTEM (GPS) IFR APPROACHES PASS FAA FLIGHT INSPECTION AND WILL HELP SAVE LIVES FOR MARYLAND RESIDENTS**
3 September, 1997	**HEADLINE: PRIVATELY DEVELOPED GLOBAL POSITIONING SYSTEM (GPS) IFR APPROACHES PASS FAA FLIGHT INSPECTION AND WILL HELP SAVE LIVES FOR RURAL PENNSYLVANIA**
23 September, 1996	**HEADLINE: Global Positioning System (GPS) TECHNOLOGY IMPROVES SAFETY AND HELPS TO SAVE LIVES FOR PA AIR MEDICAL TRANSPORT PROGRAM**

Heli-Expo Edition February 9, 1999

HEADLINE: SATELLITE TECHNOLOGY IMPLEMENTATION (STI) DEVELOPS OVER ONE HUNDRED IFR "COPTER" GLOBAL POSITIONING

SYSTEM (GPS) APPROACHES.

Satellite Technology implementation *(STI)*, LLC., of Orange Beach, Alabama, has been pioneering the development of helicopter GPS nonprecision approaches since the company was establishment in June, *1995.* As of Heli-Expo 1999, the number of STI approaches developed by *STE* is *105* procedures; and includes the implementation of the world's first and largest "IFR Network? to provide inter-heliport IFR operations.

Satellite Technology Implementation *(ST.!)*, L.L.C. became the first company authorized by the Federal Aviation Administration (FAA) as qualified to develop Global Positioning System (GPS) instrument approaches m February, 1998. In the past year alone, since gaining FAA approval, *STE* has developed, or is various stages of completion, of sixty six approach procedures.

"The majority of our customers have been Emergency Medical Services (EMS) programs," said Stephen M. Hickok, *STI* Managing Owner." In the past, many regional hospitals have been under-served during periods of marginal weather. *STI's* "networks of GPS approaches" enhance safety and increase operational capabilities, with flights between outlying referring hospitals, and the receiving trauma facilities, under Instrument Flight Rules (IFR) during periods of low ceiling or visibility weather conditions." *STE* has also been contracted by corporate flight departments to provide similar capabilities.

TI provides services under special authorization by the Federal Aviation Administration to complete on-site visits and data collection, accomplish airspace, environmental and FAA coordination, and develop final approach 'packages in support of meeting the growing IFR needs of the helicopter industry. STI uses a proprietary suite of Airspace Engineering Software (AES) © tools to complete airspace planning and approach procedure development, in a fraction of the time and increased reliability than conventional methods.

In 1997 *STI* completed the first EMS "IFR network" consisting of eleven approaches for STAT MedEvac, of Pittsburgh, PA. Since then, *STI* has completed a nineteen approach "network" for Hillcrest HealthCare, of Tulsa, Oklahoma, and has this month completed flight inspection of a twenty two approach "network" for St. Vincent's Life Flight program, of Toledo, Ohio, and an additional five approaches to increase STAT MedEvac's "network" to sixteen approaches. "I'm particularly pleased for the STAT MedEvac additions," said Hickok, "which is evidence that their IFR *network* has proven successful."

Other *STI* customers include the Maryland State Police, Keystone Helicopters, Mayo One, the University of Wisconsin, the University of Michigan, Butterworth Hospital, Mobile Oil, General Electric, and Sikorsky Helicopters.

Visit *STI* at the Heli-Expo booth #2223

Satellite Technology Implementation, L.L.C.

FOR IMMEDIATE RELEASE - 16 October, 1998

HEADLINE: IFR NETWORK OF SIX GLOBAL POSITIONING SYSTEM (GPS) APPROACHES WILL HELP SAVE LIVES FOR RURAL WISCONSIN

Satellite Technology implementation *(STI)*, LLC., of Orange Beach, Alabama, was contracted by the University of Wisconsin Hospital and Clinics, of Madison, Wisconsin, in November, 1997, to develop five GPS approaches for their Med Flight Emergency Medical Services (EMS) helicopter program. The five new GPS approaches will service hospitals throughout rural Wisconsin, and establish an IFR 'network' of approaches linked to Copter GPS 180 approach, commissioned m late 1994 into the University's Trauma Center.

"We are eager to begin using these GPS approaches to fly direct from our helipad to the five helipads in Instrument Flight Rules (IFR) conditions," said Mark Hanson, Program Director for Med Flight. "This will carry our service to the citizens of those areas in times where we would have had to make alternate arrangements to assist referral hospitals and their patients."

In 1994, the University of Wisconsin Hospital and Clinics participated with the FAA's vertical flight program office during original flight testing to establish helicopter GPS approach criteria. As one of the original four industry partners, the University's Copter GPS 180 approach was the second Copter GPS approach commissioned in the world.

"Med Flight's GPS approach to the University hospital was only one side of the solution necessary to provide all weather EMS services. They still had to fly under Visual Flight Rules (VFR) to the referral hospitals to pick up the patient. Now, with a 'network' of GPS approaches between outlying referring hospitals, and the University's trauma facilities, safety and operational capabilities for Med Flight are enhanced when called upon during periods of low ceiling or visibility weather conditions, by allowing the entire flight to be conducted under Instrument Flight Rules (IFR)," said Stephen M. Hickok, STI Managing Owner.

STI provides services under special authorization by the Federal Aviation Administration to complete on-site visits and data collection, accomplish airspace, environmental and FAA coordination, and develop final approach 'packages', m support of meeting the growing [FR needs of the helicopter industry. STI developed an approach procedure to each of the University's frequented sites, using their proprietary suite of Airspace Engineering Software (AES) © tools, and submitted approach procedures to FAA for administrative review, processing, and flight inspection. Flight inspection was completed by a combined FAA and STI team on July 15th, 1998, using Med Flight's helicopter, which is leased and operated by Corporate Jets, Inc., of West Mifflin, Pennsylvania.

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Satellite Technology Implementation L.L.C.

FOR IMMEDIATE RELEASE -11 September, 1998

HEADLINE: IFR NETWORK OF NINETEEN GLOBAL POSITIONING SYSTEM (GPS) APPROACHES WILL HELP SAVE LIVES FOR RURAL OKLAHOMA

Satellite Technology Implementation (STJ), LLC., of Orange Beach, Alabama, was contracted by Hillcrest HealthCare and AirEvac of Tulsa, Oklahoma, in September, 1997, to develop a GPS [FR network of nineteen approaches serving hospitals throughout the eastern half of Oklahoma.

“In the past, many regional hospitals associated with Hillcrest have been under served during periods of marginal weather. By working with STI, AirEvac has been able to expand its critical care transport capability in just a year’s time. Now, when every second counts, communities throughout eastern Oklahoma can count on AirEvac and the [FR network of GPS approaches,” said Donald A. Lorack, Jr., President and CEO of Hillcrest HealthCare.

“AirEvac’s network of GPS approaches enhance safety and increase operational capabilities with flights between outlying referring hospitals, and HillCrest’s heliport, under Instrument Flight Rules ([FR) during periods of low ceiling or visibility weather conditions,” said Stephen M. Hickok, STI Managing Owner.

STE provides services under special authorization by the Federal Aviation Administration to complete on-site visits and data collection, accomplish airspace, environmental and FAA coordination, and develop final approach ‘packages’, in support of meeting the growing [FR needs of the helicopter industry. STI developed an approach procedure to each of AirEvac’s sites, using their proprietary suite of Airspace Engineering Software (AES) © tools, and submitted approach procedures to FAA for administrative review, processing, and flight inspection. Flight inspection was completed by a combined FAA and STI team on June 23rd, 1998, using a helicopter leased by Sit. FAA flight inspectors used STI’s AES © tools to supplement their own Global Positioning System Flight Inspection System (GFIS).

“As one of the nation’s visionary health systems, Hillcrest openly supported the development of an [FR GPS network. A project of this kind provides an additional resource for critical care transport and strengthens the continuum of care linkage between community hospitals and a fully integrated healthcare delivery system. Approach site selections were based on past weather experience and operational need,” voiced Tammy Brown, AirEvac’s Program Director.

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Satellite Technology Implementation, L.L.C.

FOR IMMEDIATE RELEASE - 5 September, 1998

HEADLINE: SATELLITE TECHNOLOGY IMPLEMENTATION (STI) DEVELOPS GPS INSTRUMENT APPROACH PROCEDURES.

Satellite Technology Implementation (Sit), L.L.C. is the first company authorized by the Federal Aviation Administration (FAA) as qualified to develop Global Positioning System (GPS) instrument approaches. The agreements were reached in meetings between Sit and FAA on February 2nd through February 5th,, 1998, which were held in Oklahoma City, Oklahoma. In attendance were Sit managing owners Stephen Hickok and Daniel Norman and FAA representatives from Aviation System Standards (AVN) and Flight Standards (AFS). Agreements were finalized in an FAA letter dated May 13th, 1998.

STE has completed twenty-nine approaches in the first six months since agreements were reached with FAA, and are already in various stages of work for an additional fifty-one approaches this year. “Operators who desire an approach procedure now have an alternative to services previously available only by FAA,” said STE co-owner, Daniel Norman.

According to the agreement, Sit will work directly with proponents to identify requirements, gather data and perform on-site evaluations, accomplish airspace, environmental and agency coordination, and develop and submit completed approach procedure packages for administrative review and flight inspection by FAA.

“Developing the approach procedure is only a percentage of the entire effort necessary to develop a safe and operationally effective IFR capability,” said Hickok. “STE guides the project through the ‘maze’ of FAA offices and requirements. We travel to each proposed site, work with FAA to coordinate airspace, environmentals, and air traffic, develop approach procedures based upon data validated during on-site visits, coordinate and assist FAA flight inspection, provide NavData and approach charting, and assist our clients with changes to training manuals and operations specifications.”

Another STI first was agreed to under a separate new policy by FAA which-allows Sit to develop GPS approaches using their proprietary suite of software tools. STI’s software tools incorporates the use of current digital terrain and obstacle databases, Terminal Instrument Procedures (TERPS) criteria, and allows Sit to develop approach procedures with repeatable quality, and in a fraction of the time it takes developers using paper charts.

“This results in a safer approach, by eliminating human error by developers, and delivers the lowest possible approach minimums for our clients,” says Hickok.

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Satellite Technology Implementation, L.L.C.

FOR IMJVIEDJATE RELEASE - 1998 Heli-Expo Announcement

FEBRUARY 15, 1998

HEADLINE: THE FEDERAL AVIATION ADMINISTRATION RECOGNIZES SATELLITE TECHNOLOGY IMPLEMENTATION TO DEVELOP GLOBAL POSITEONING SYSTEM HELICOPTER INSTRUMENT APPROACHES.

Satellite Technology Implementation *(STJ),* L.L.C., has been acknowledged by the Federal Aviation Administration (FAA) as qualified to develop Global Positioning System (GPS) instrument approaches. The agreements were reached in meetings between *STI* and FAA on February 2nd through February 5th , 1998, which were held in Oklahoma City, Oklahoma. In attendance were *STI* managing owners Stephen Hickok and Daniel Norman and FAA representatives from Aviation System Standards (AVN) and Flight Standards (AFS).

"This finalizes efforts began two and one-half years ago that *STI* is both qualified and capable of developing Standard Instrument Approach Procedures (SIAPs)," said Steve Hickok, managing owner of *STI.* "Operators who desire an approach procedure are now offered an alternative to those services previously available only by FAA."

FAA is establishing new policy for allowing 'outside sources' to develop instrument approach procedures which will then be submitted to AVN for quality control and flight checks. "This will allow *STI* to reduce the time it takes us to complete IFR approaches for our customers," said Daniel Norman, co-owner of *STI.* "This also makes it possible for *STI* to make any necessary changes to the approach procedure during flight inspection."

A separate new policy was agreed to by FAA which allows *STI* to develop GPS approaches using their proprietary suite of software tools. *STI's* software tools incorporates the use of current digital terrain and obstacle databases, and the ability to develop an approach procedure which 'best fits' any environment. This results in a safer approach with the lowest possible approach minimums for their clients.

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Satellite Technology Implementation, L.L. C.

FOR IMMEDIATE RELEASE

December 3, 1997

HEADLINE: PRIVATELY DEVELOPED GLOBAL POSITIONING SYSTEM (GPS) [FR APPROACHES PASS FAA FLIGHT INSPECTION AND WILL HELP SAVE LIVES FOR MARYLAND RESIDENTS

Satellite Technology Implementation (STI), LLC., of Orange Beach, Alabama, has completed flight inspection for certification of three helicopter IFR GPS approaches into the Baltimore, Maryland area. STI was contracted by the Federal Aviation Administration (FAA) for the joint government and industry project, which was designed to leave certified approaches in place, and document the value and effectiveness designees or contractors offer for the development of special instrument approach procedures. All three instrument approach procedures will be used by the Maryland State Police Aviation Division for Emergency Medical Services (EMS) transportation into one of several Baltimore downtown medical centers. “We designed one approach as a point in space procedure to Fort McHenry” says Steve Hickok, founder and managing owner of STI. “The Fort McHenry approach will be use for delivering patients to any one of Baltimore’s medical centers.” Those medical facilities include: R. Adams Shock Trauma, Montabello Hospital, Hopkins Bayview Hospital, and Johns Hopkins Hospital. Each facility possesses specialized medical capabilities, and each will be serviced by this single approach procedure. A second approach was designed to deliver patients directly to R. Adams Shock Trauma, and the third approach was designed by STI to Maryland State Police trooper-6 post, located in Centreville, Maryland. The trooper-6 approach will be used as a pick up point for critical patients needing transport from the eastern shore area during [FR weather. All three procedures were flight inspected by FAA on December 1st through 3rd, using a Maryland State Police helicopter and pilot/trooper, and assisted by STI. STE provided services which included: initial on-site data collection visits, an implementation plan and benefit/cost report, pilot IFR/GPS training, approach procedures development, environmental assessments, flight inspection, and airways facilities and air traffic coordination’s. STE used their proprietary computer software for the development of all three instrument approach procedures. According to STI’s Benefit/Cost report, Maryland State Police can anticipate recovering sixty-eight percent of those flights historically cancelled each year for weather. STI bases their Benefit/Cost Analysis upon actual historical flight records, and an averaged forty years of weather data which they purchase from NOAA. IFR-weather influences used in STI’s calculations include ceiling, visibility, thunderstorms, fog, and icing. With the completion of the three approach procedures for Maryland State Police, STI has developed a total of fifteen nonprecision GPS approach procedures during the 1997 calendar year.

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September 3, 1997

HEADLINE: PRIVATELY DEVELOPED GLOBAL POSITIONING SYSTEM (GPS) [FR APPROACHES PASS FAA FLIGHT INSPECTION AN]) WILL HELP SAVE LIVES FOR RURAL PENNSYLVANIA

Satellite Technology Implementation (STI), LLC., of Orange Beach, Alabama, has completed flight inspection for certification of the world’s largest helicopter IFR network of GPS approaches. STI was contracted by STAT MedEvac, of Pittsburgh, Pennsylvania, one year earlier for the GPS project. STI used their own proprietary Instrument Approach Procedure Automation (IAPA) software tools and developed the eleven nonprecision GPS approaches, and managed the project through completion of FAA flight inspection. Flight inspection was completed by an FAA/industry group on 31 July, 1997, using a Corporate Jet’s BK117 helicopter leased by Sit and FAA’s new portable GPS Flight Inspection System (GFIS). “The helicopter industry has never enjoyed a heliport to heliport [FR capability,” Steve Hickok, STI owner and manager, points out. “GPS has changed all of that. STAT MedEvac now has all weather capabilities to fly direct to outlying hospital heliports located through out western Pennsylvania, and return patients directly to trauma center heliports in downtown Pittsburgh." STAT MedEvac, a service of the Center for Emergency Medicine, is one of the nation's largest air medical transport programs with seven helicopters based throughout western Pennsylvania. STAT MedEvac transports more than 5,000 patients a year. "Western Pennsylvania is known for its changeable weather, improving our ability to fly to rural areas during periods of marginal weather will ultimately save more lives and increase access to higher levels of health care," explains James Bothwell, Director of Operations, STAT MedEvac. STI also completed flight inspection on 31 July for a helicopter GPS approach to Robert Packer Hospital, of Sayre, Pennsylvania. STI utilized their JAPA program and completed the Sayre approach within six months of being contracted by Keystone Helicopter Corporation, of West Chester, Pennsylvania.

STI provides instrument approach procedure development and project management for the implementation of GPS instrument approach procedures, for airports and heliports in need of IFR enhancements.

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23 SEPTEMBER 1996

HEADLINE: Global Positioning System (GPS) TECHNOLOGY IMPROVES SAFETY AND HELPS TO SAVE LIVES FOR PA AIR MEDICAL TRANSPORT PROGRAM

STAT MedEvac, located in Pittsburgh, Pennsylvania, has contracted with Satellite Technology Implementation of Manassas, Virginia, for the implementation of a network of thirteen GPS approaches. These approaches are being coordinated by Satellite Technology Implementation for commissioning by the Federal Aviation Administration. The approaches will enable STAT MedEvac to fly to out-lying hospitals located through out the western portion of Pennsylvania during periods of low ceilings and visibility. STAT MedEvac, a service of the Center for Emergency Medicine, is one of the nation's largest air medical transport programs with seven helicopters based throughout western Pennsylvania. STAT MedEvac transports more than 4,400 patients a year. "This project enables STAT MedEvac to reach community hospitals in rural areas so that ill patients can be air lifted to a larger more advanced hospital for care. Western Pennsylvania is known for its changeable weather, improving our ability to fly to rural areas during periods of marginal weather will ultimately save more lives and increase access to higher levels of health care," explains James Bothwell, Director of Operations, STAT MedEvac. STAT MedEvac will have the most extensive EMS helicopter [FR network in the world. This [FR system will allow STAT MedEvac to increase productivity of their IFR helicopter fleet by 15 to 20 percent. Satellite Technology Implementation offers project management and engineering services for airspace and ground infrastructure development, for the operational implementation of GPS instrument approach procedures, for airports and heliports in need of IFR enhancements.

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